

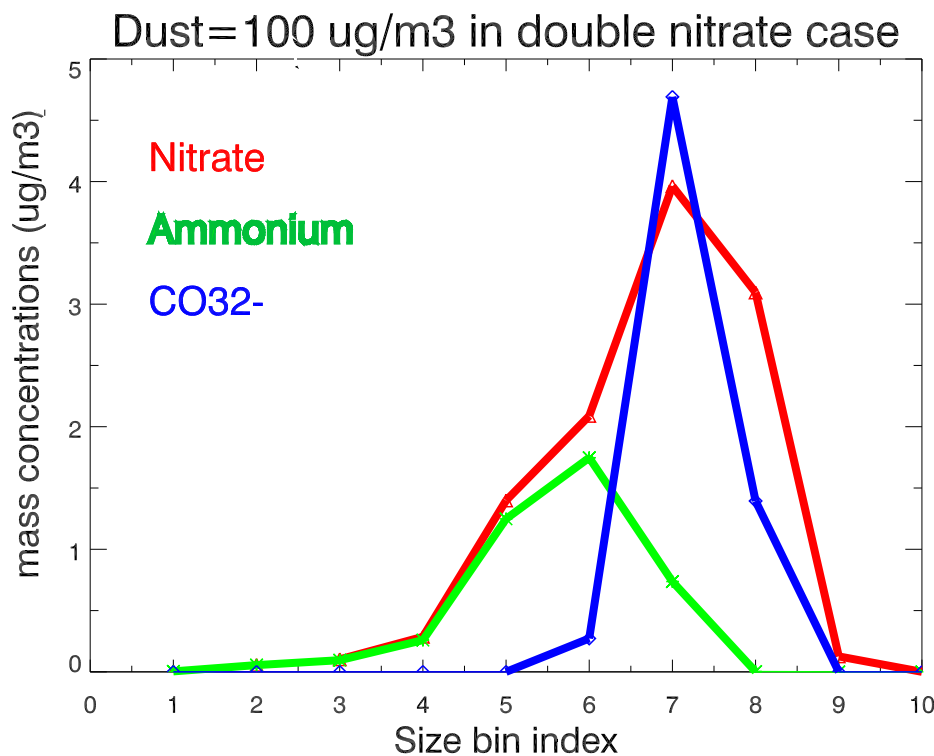
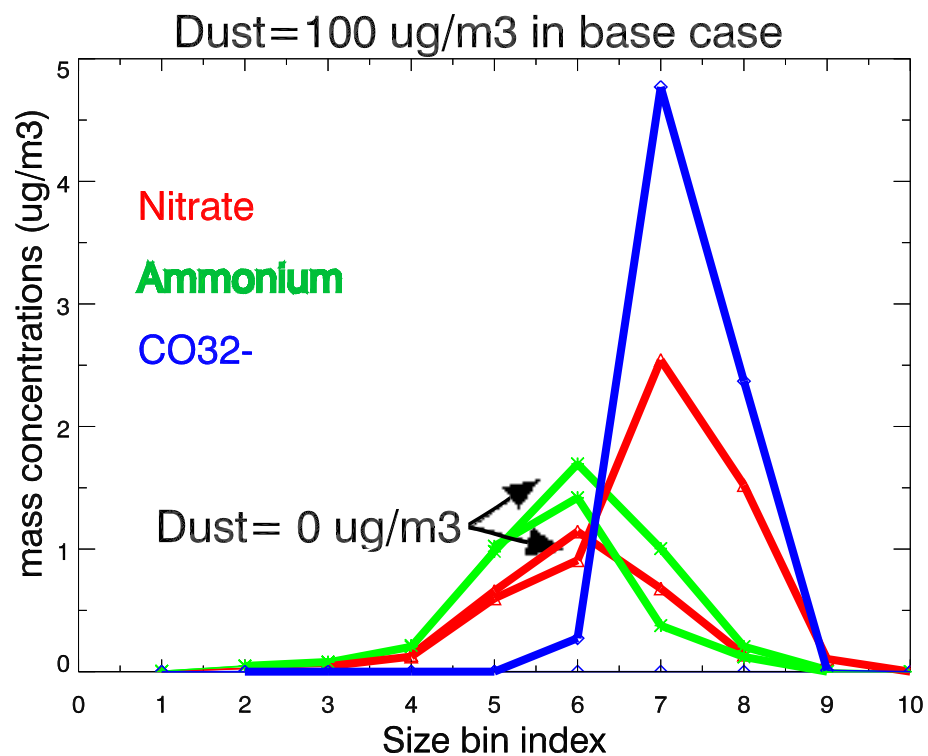
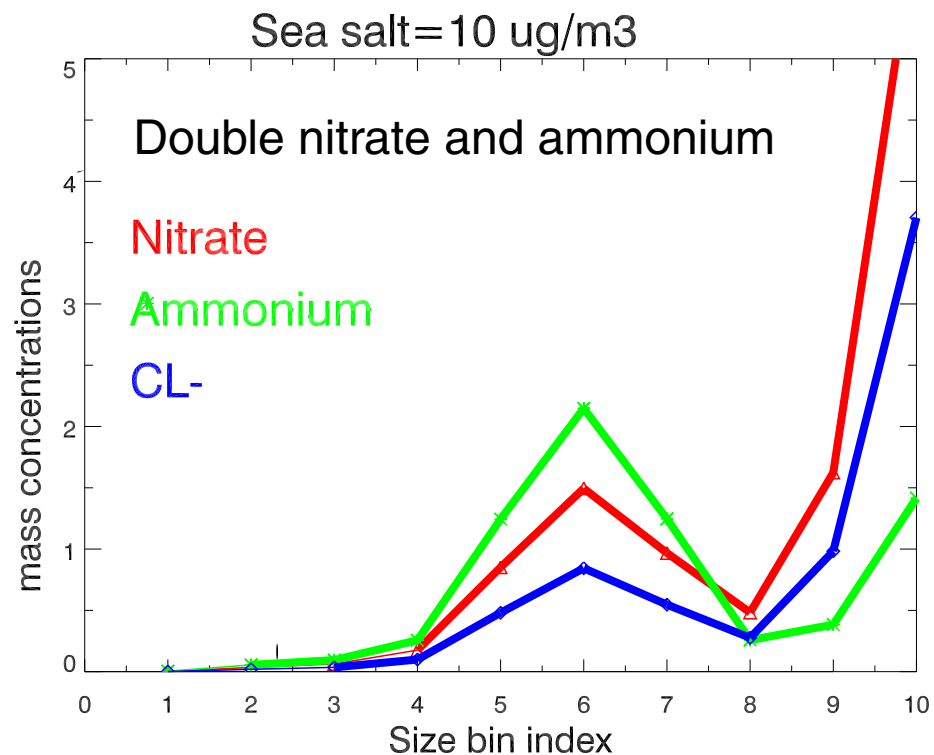
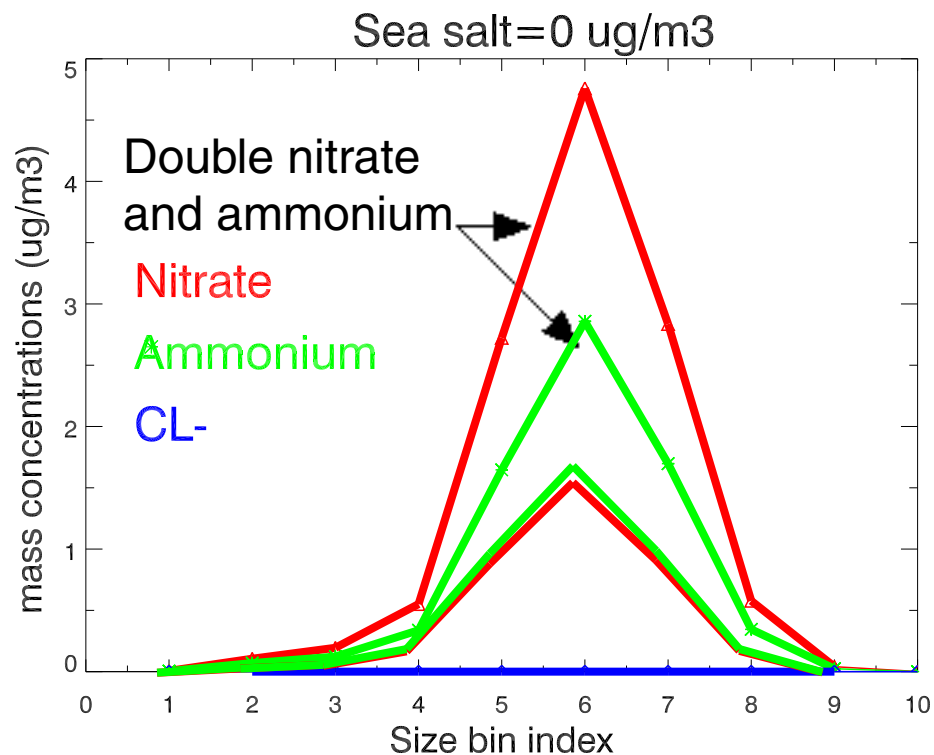
Nitrate and Ammonium in Aerosols: Effects of Dust and Sea Salt

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University of Michigan**

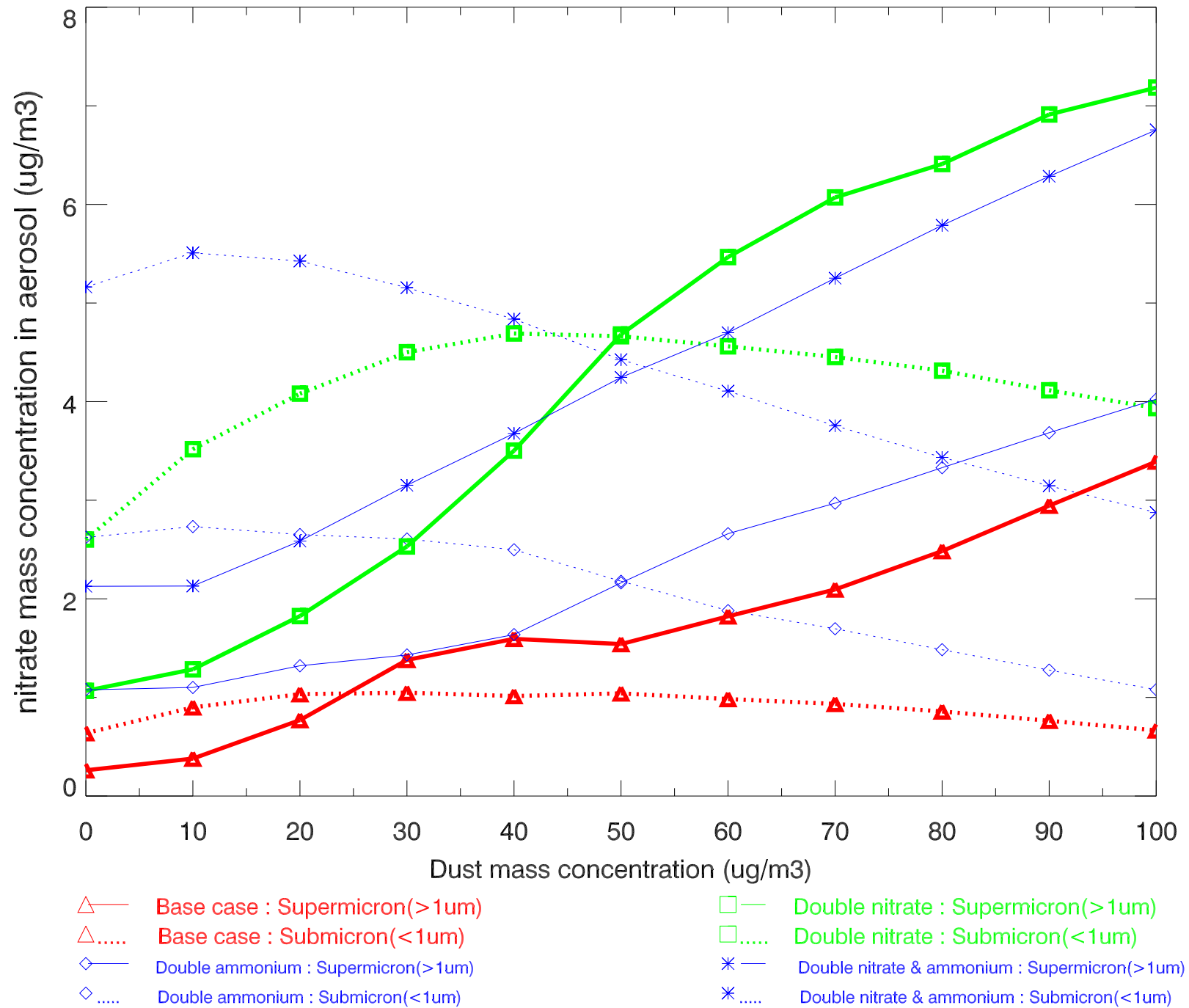
**DOE Atmospheric Chemistry Program
February 13-15, 2001**

Motivation.

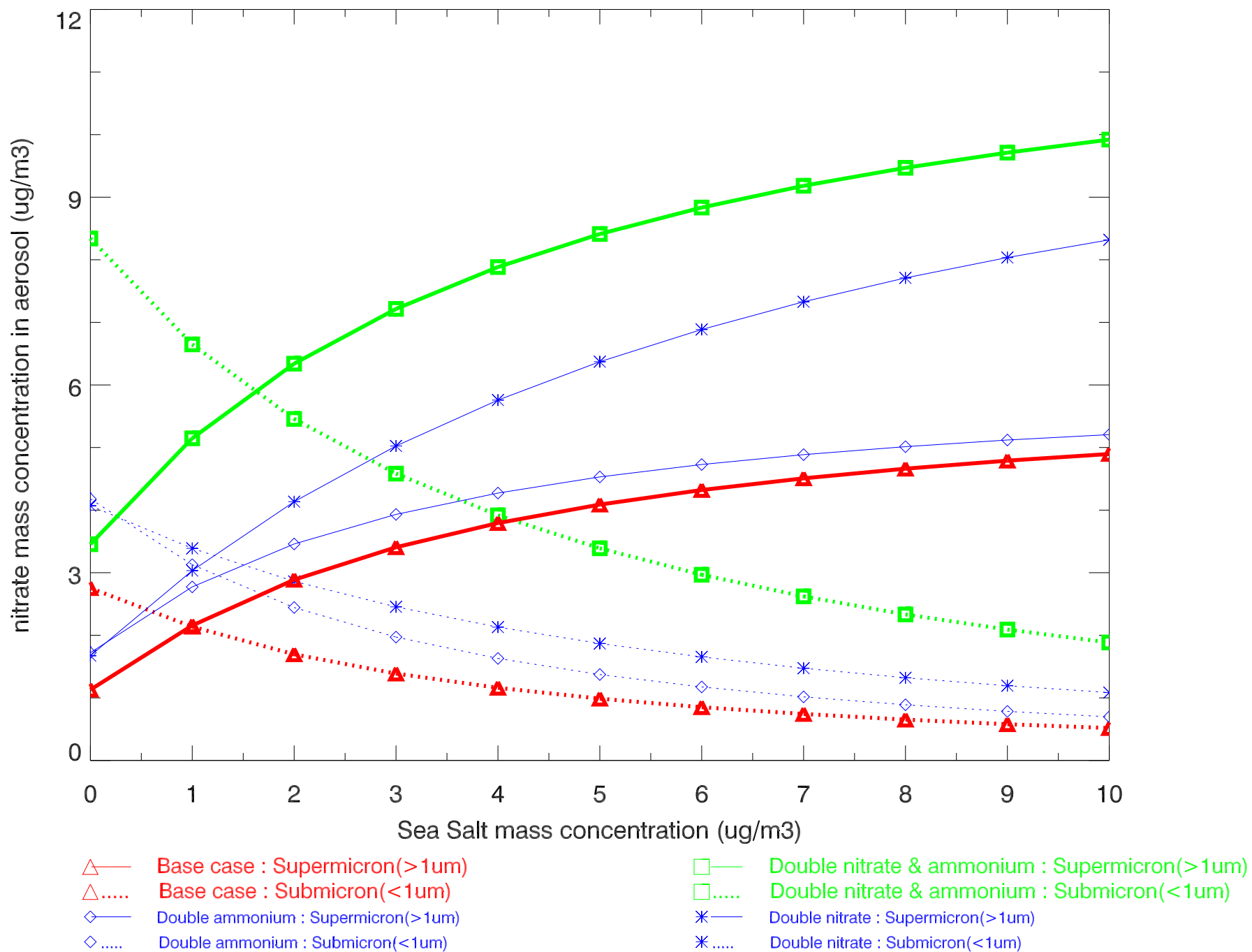
- Nitrate and Ammonium are incorporated in aerosol as a result of chemical interactions with other components of the aerosol
- Inclusion of this equilibrium may lead to changes in aerosol forcing of climate – especially in future scenarios where NO_x emissions may grow.
- The incorporation of nitrate in aerosol may lead to decreases in NO_x , thereby decreasing formation rates of ozone



Adding Dust to (SO₄²⁻,NO₃⁻,NH₄⁺) Aerosol

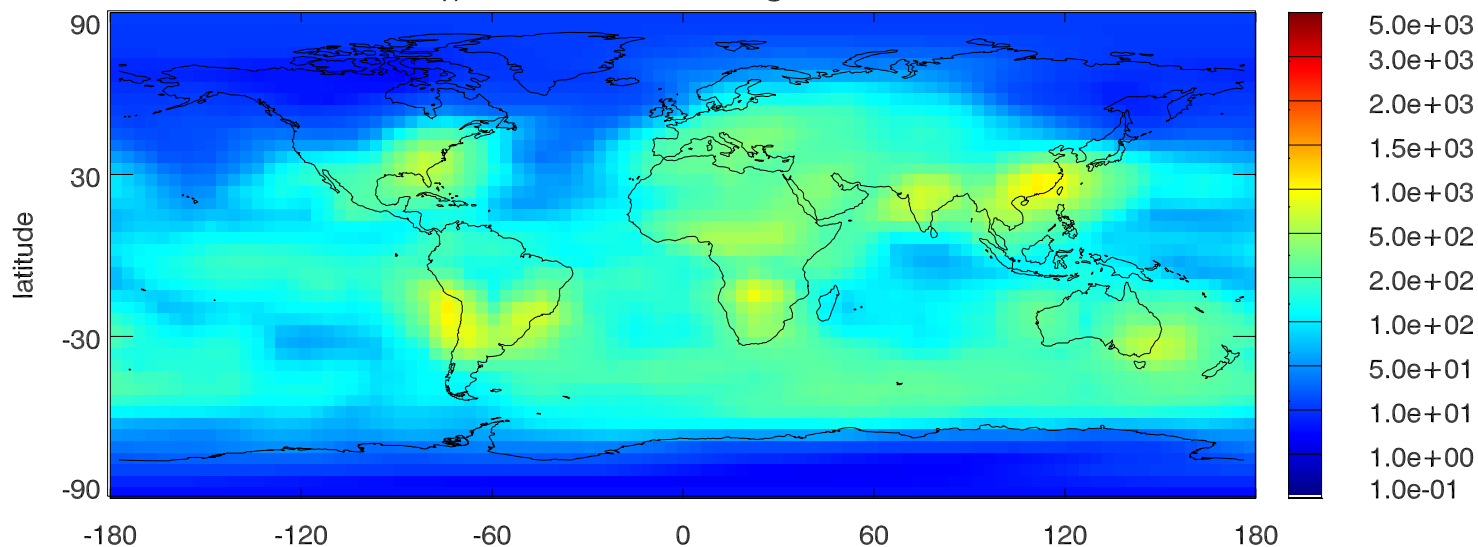


Adding Sea Salt to (SO₄²⁻,NO₃⁻,NH₄⁺) Aerosol

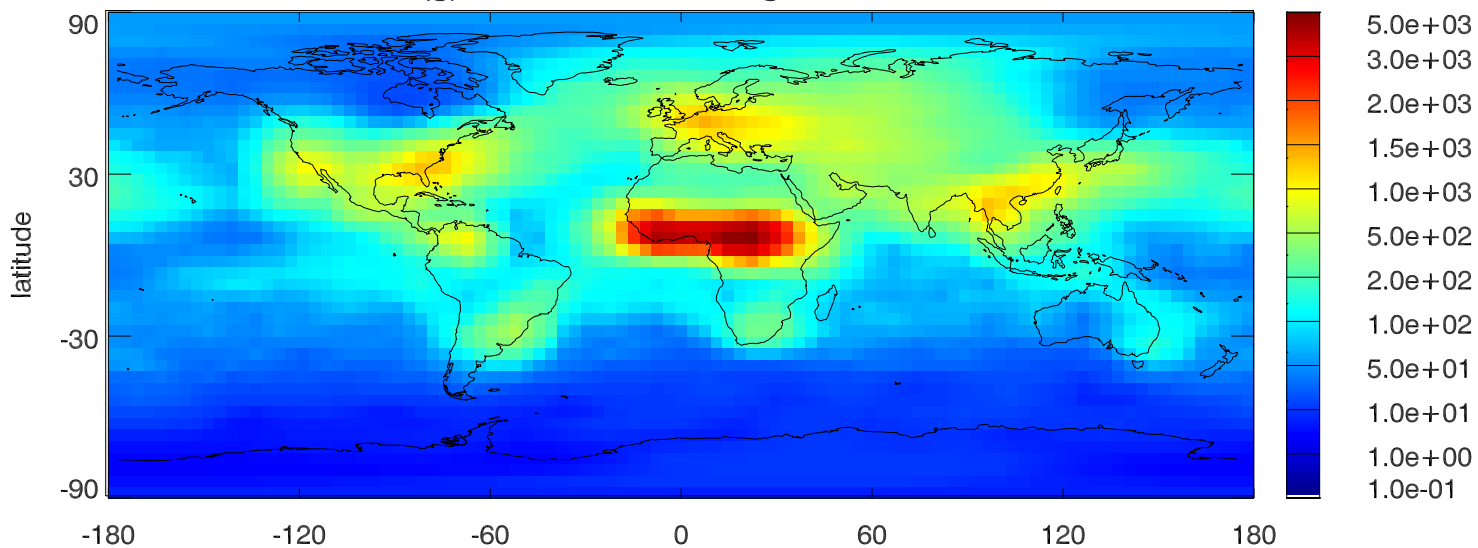


Initial mixing ratios, January

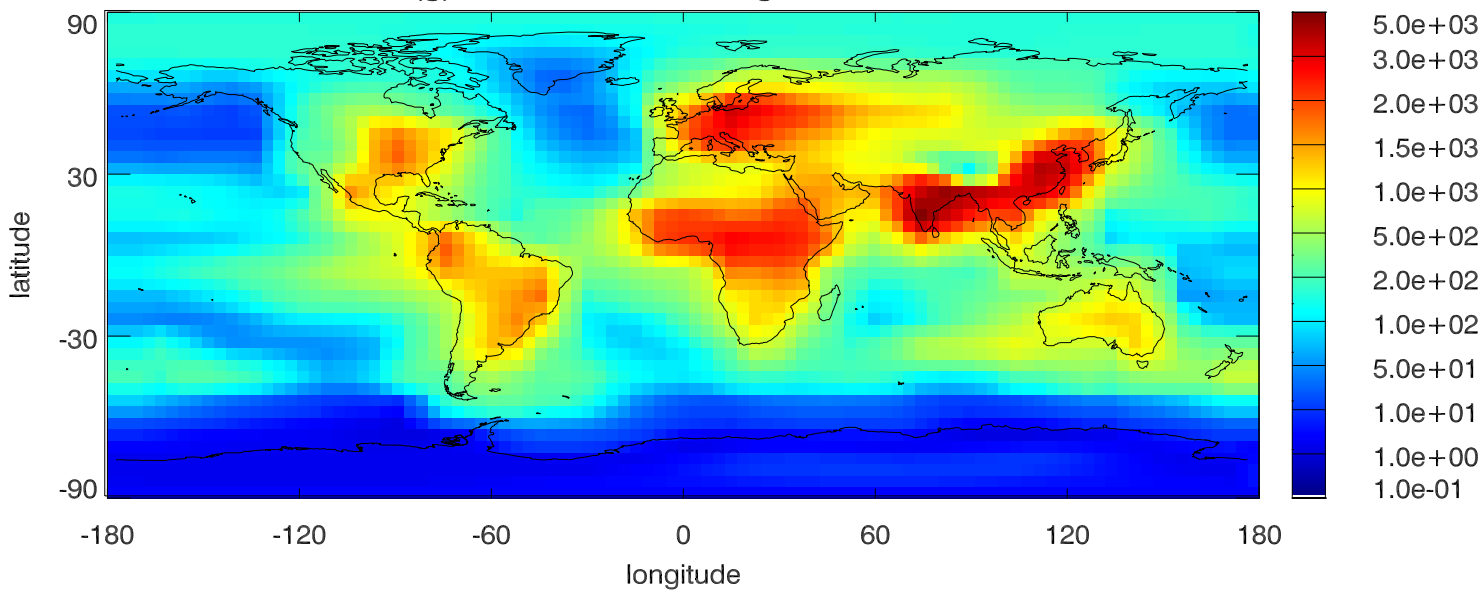
H₂SO₄(l) initial surface mixing ratio , JANUARY



HNO₃(g) initial surface mixing ratio , JANUARY

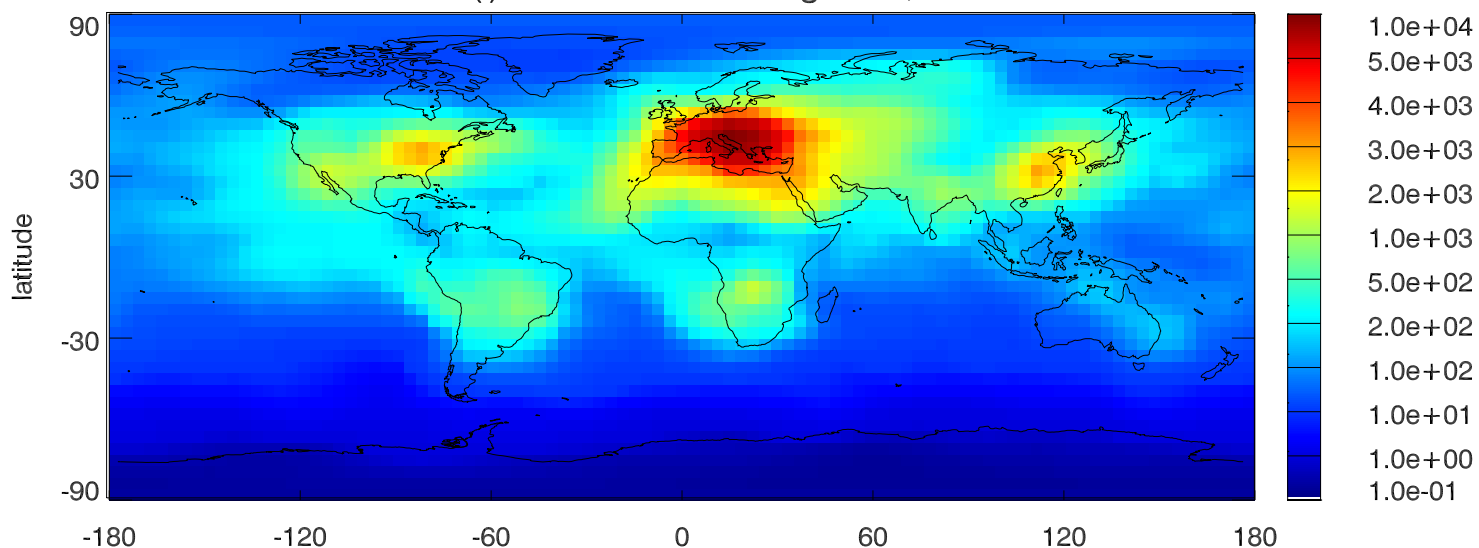


NH₃(g) initial surface mixing ratio, JANUARY

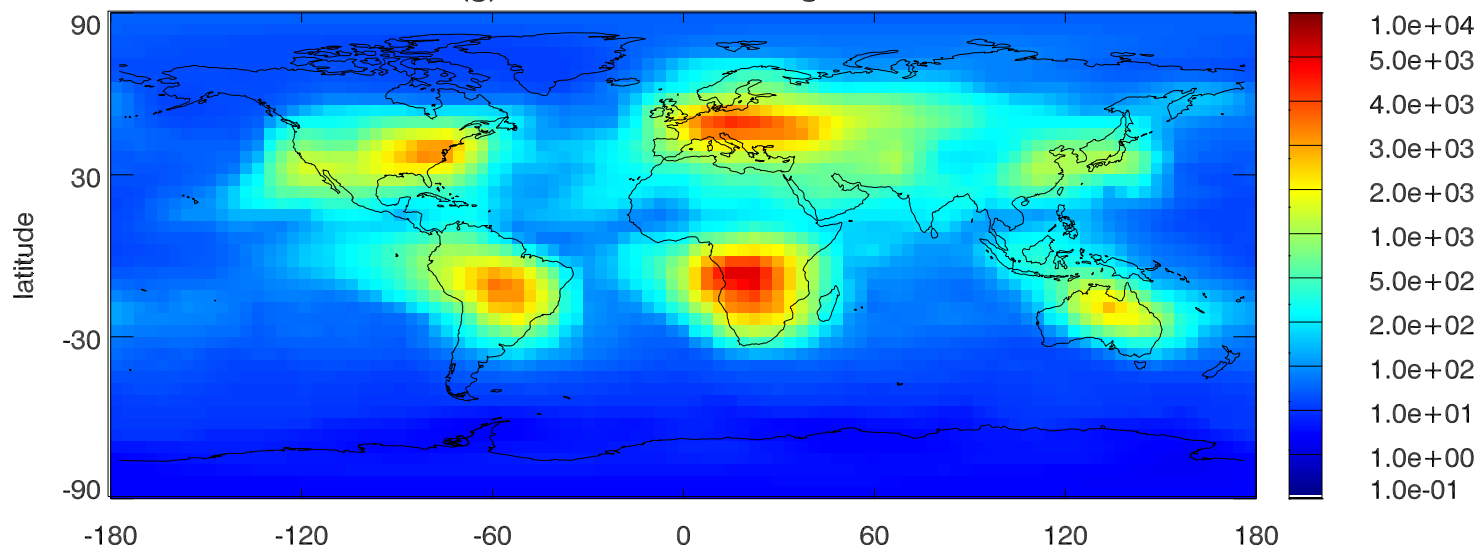


Initial mixing ratios, July

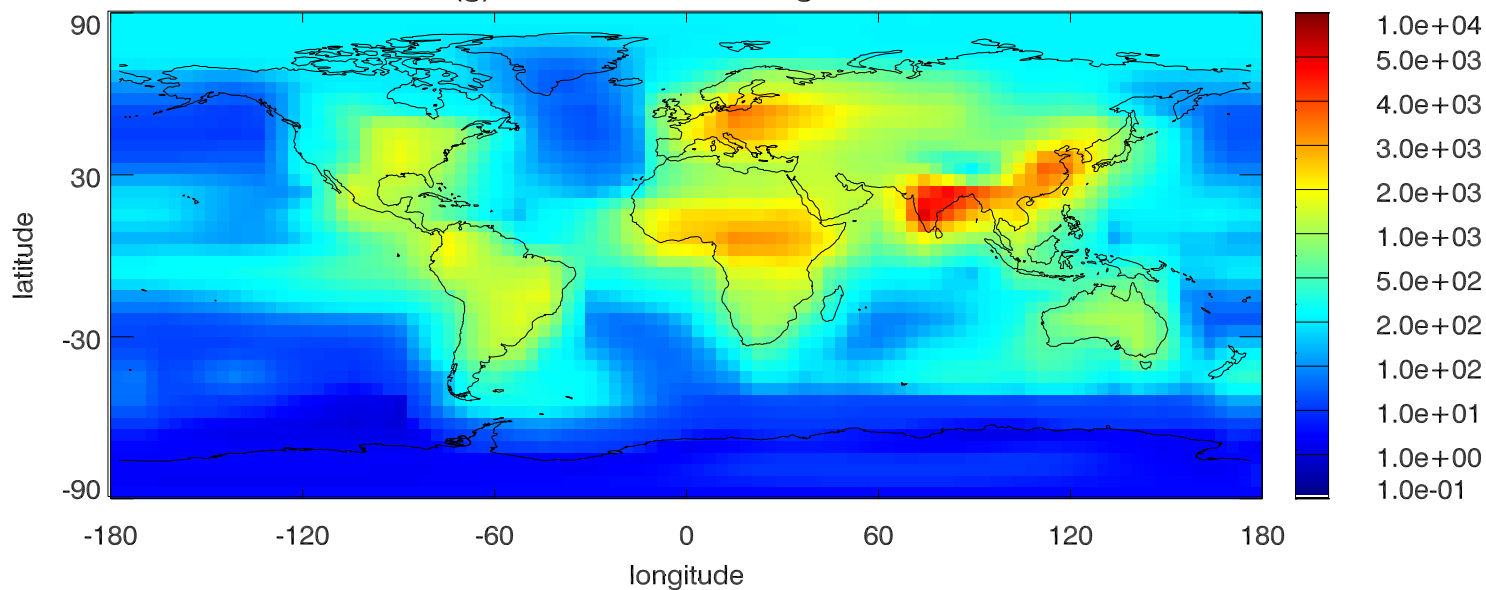
H₂SO₄(l) initial surface mixing ratio , JULY



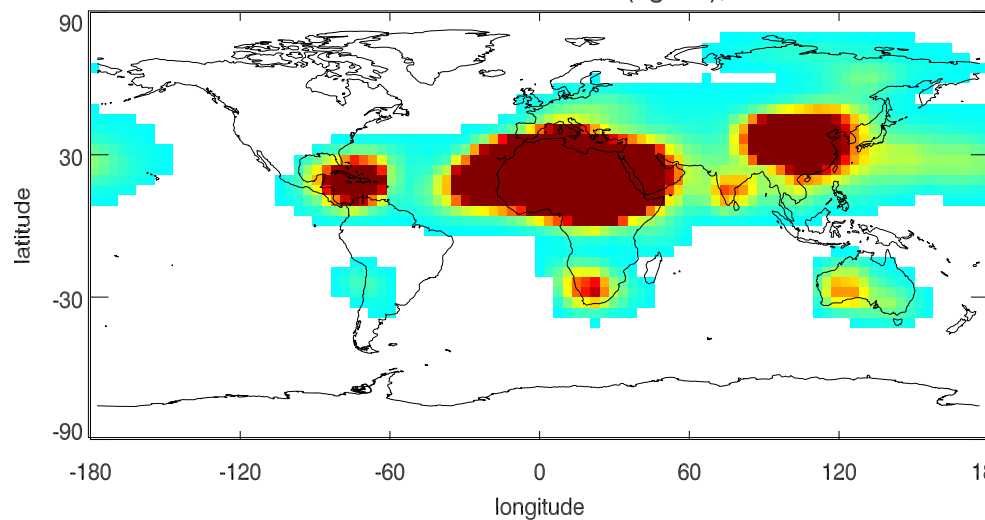
HNO₃(g) initial surface mixing ratio , JULY



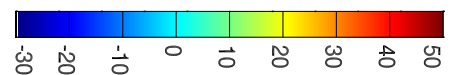
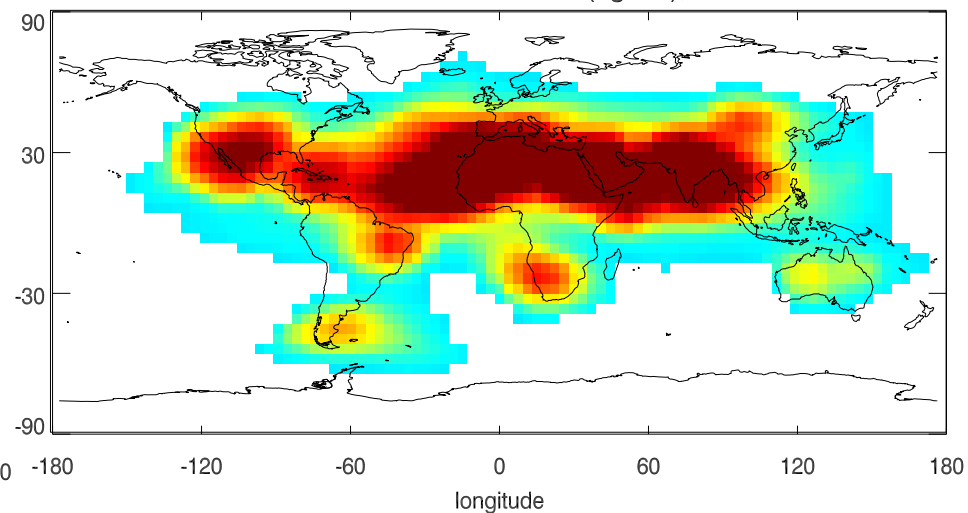
NH₃(g) initial surface mixing ratio, JULY



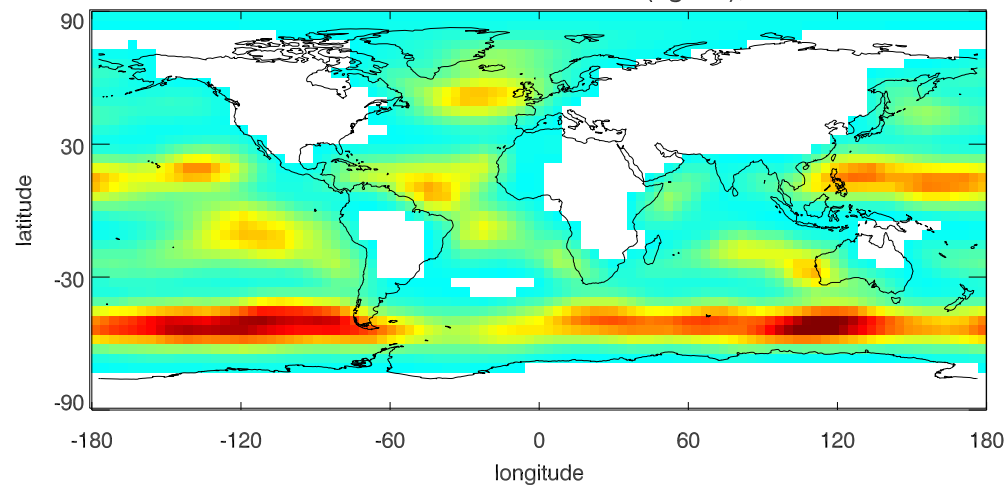
Dust surface concentration ($\mu\text{g}/\text{m}^3$), JAN



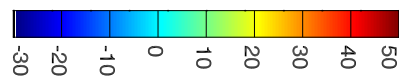
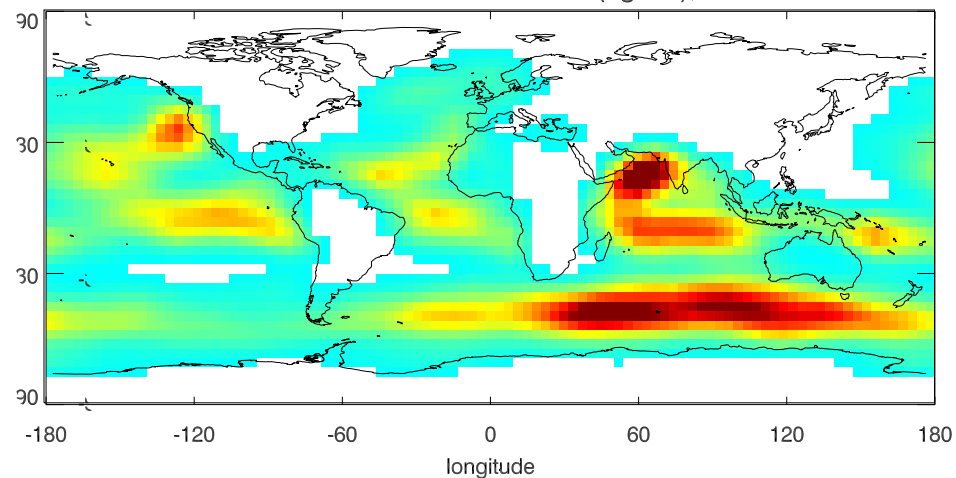
Dust surface concentration ($\mu\text{g}/\text{m}^3$), JUL



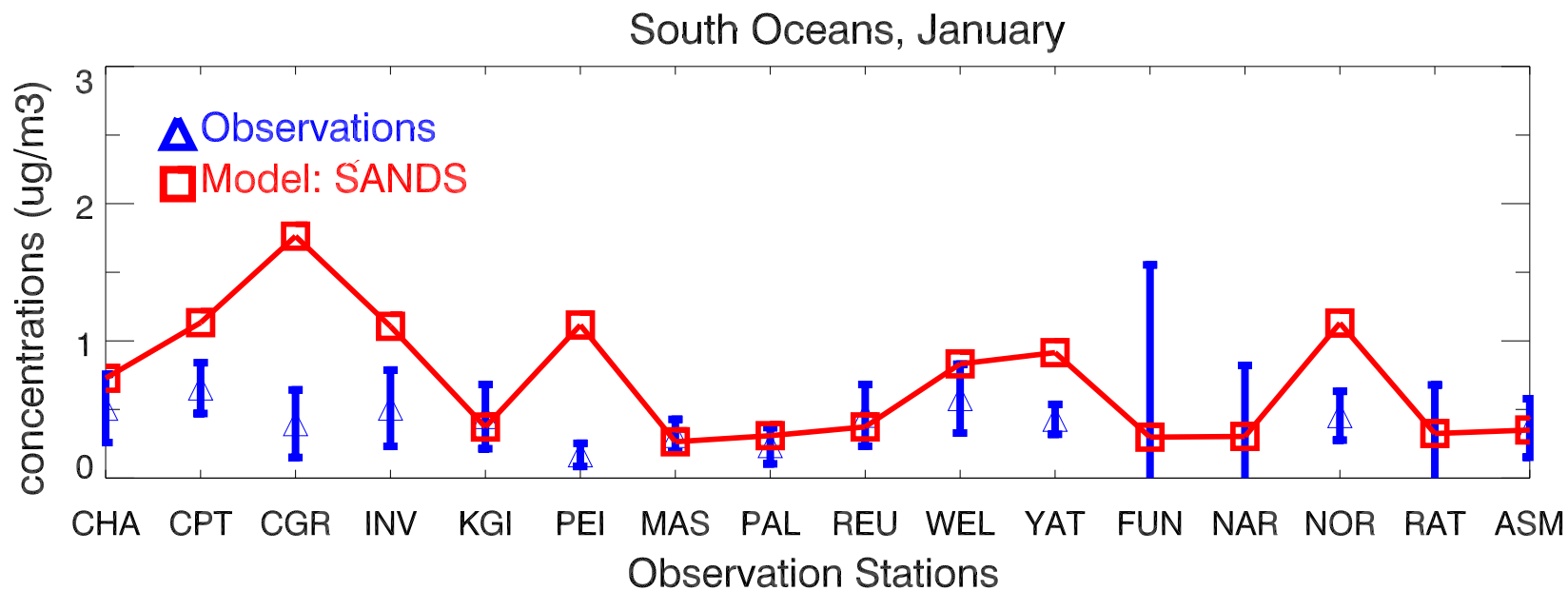
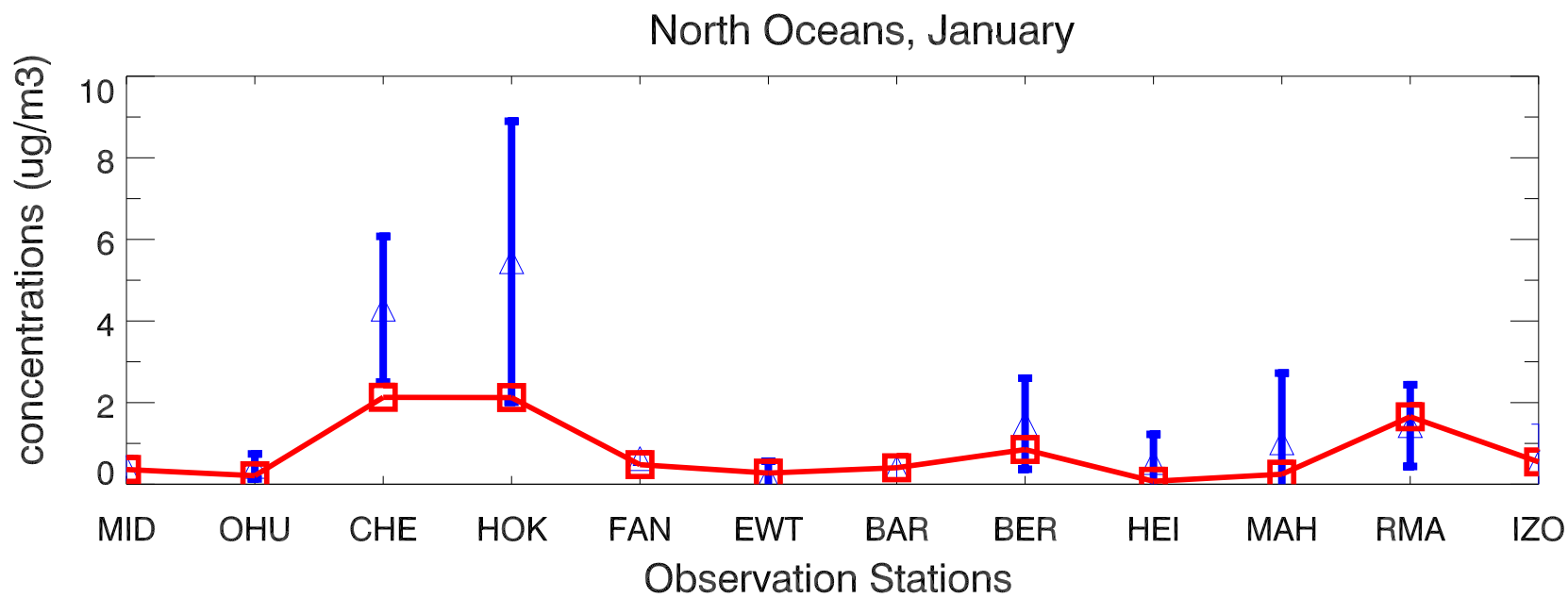
Sea salt surface concentration ($\mu\text{g}/\text{m}^3$), JAN



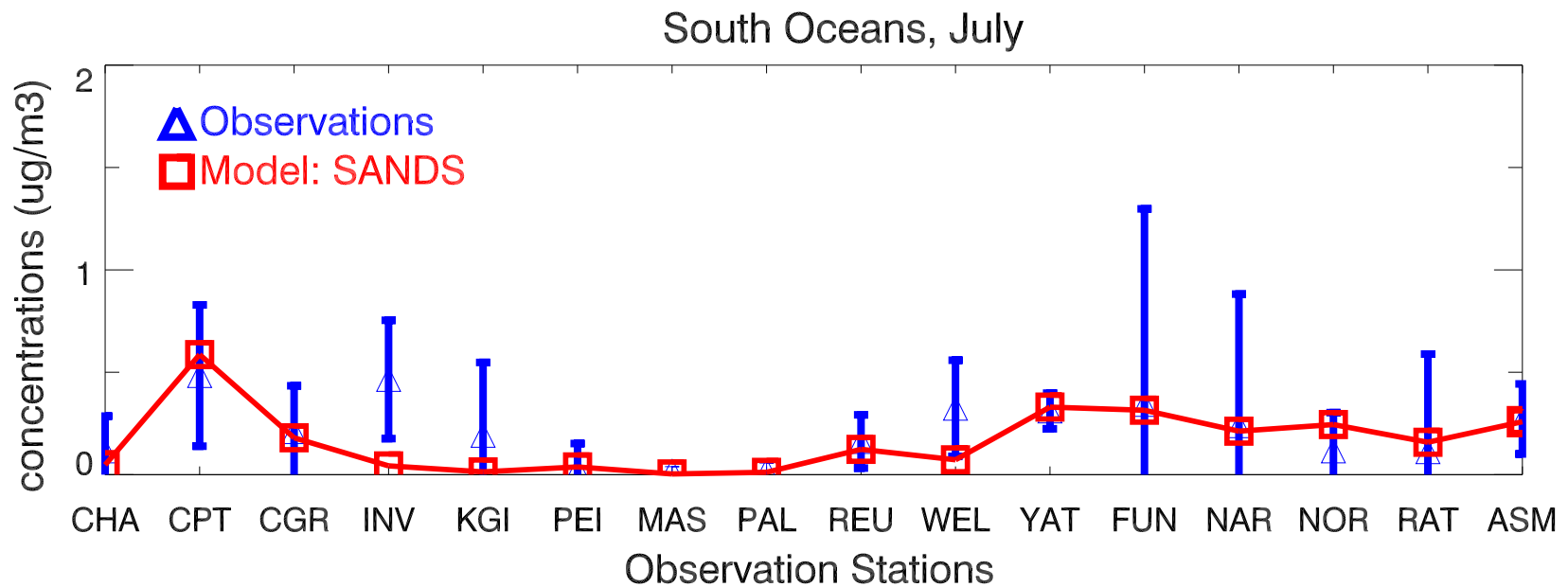
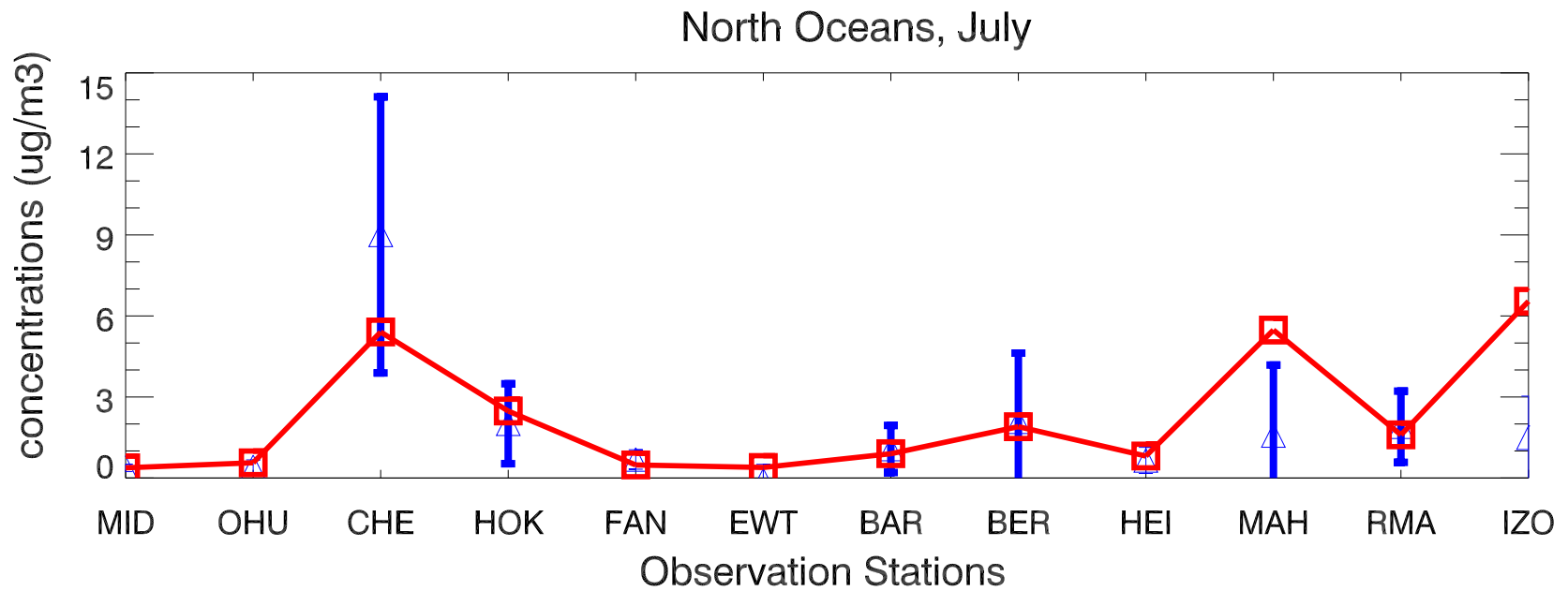
Sea salt surface concentration ($\mu\text{g}/\text{m}^3$), JUL



Comparison of SO₄- surface concentrations to observations

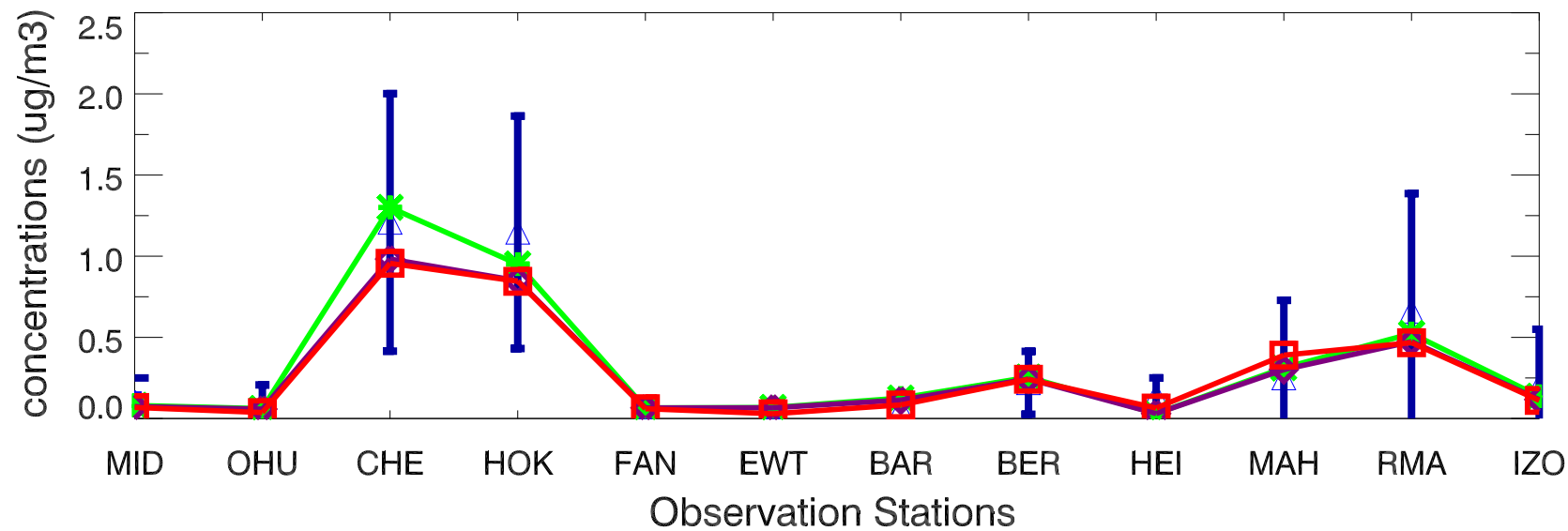


Comparison of SO₄⁻ surface concentrations to observations

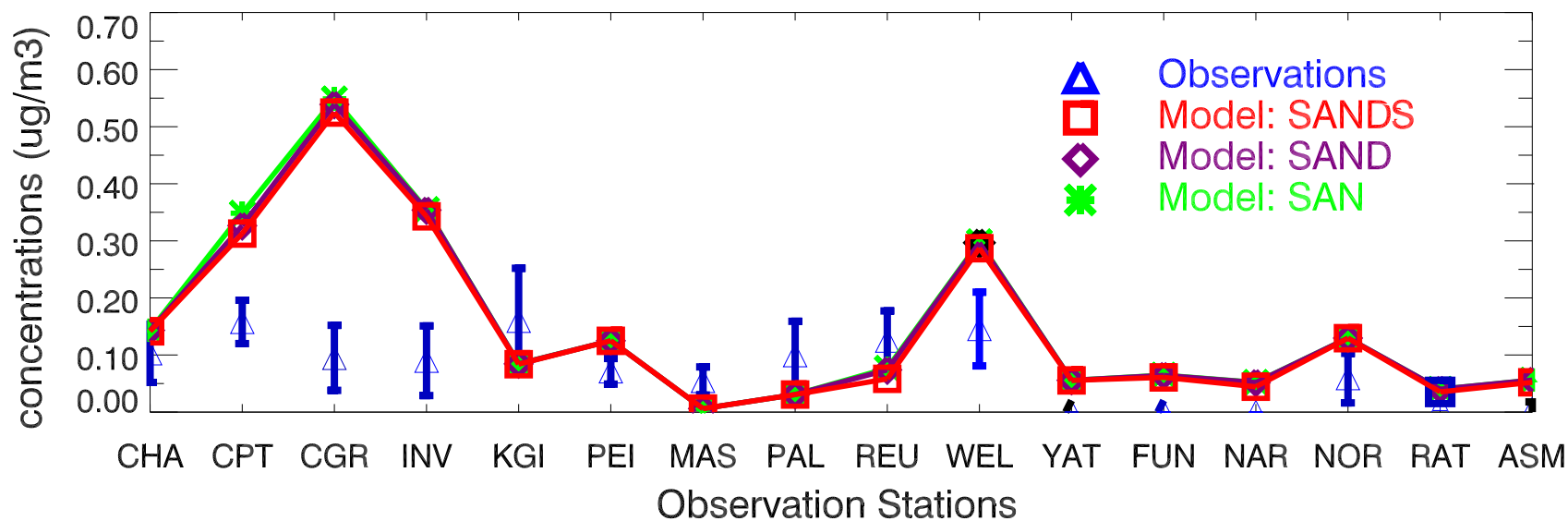


Comparison of NH₄- surface concentrations to observations

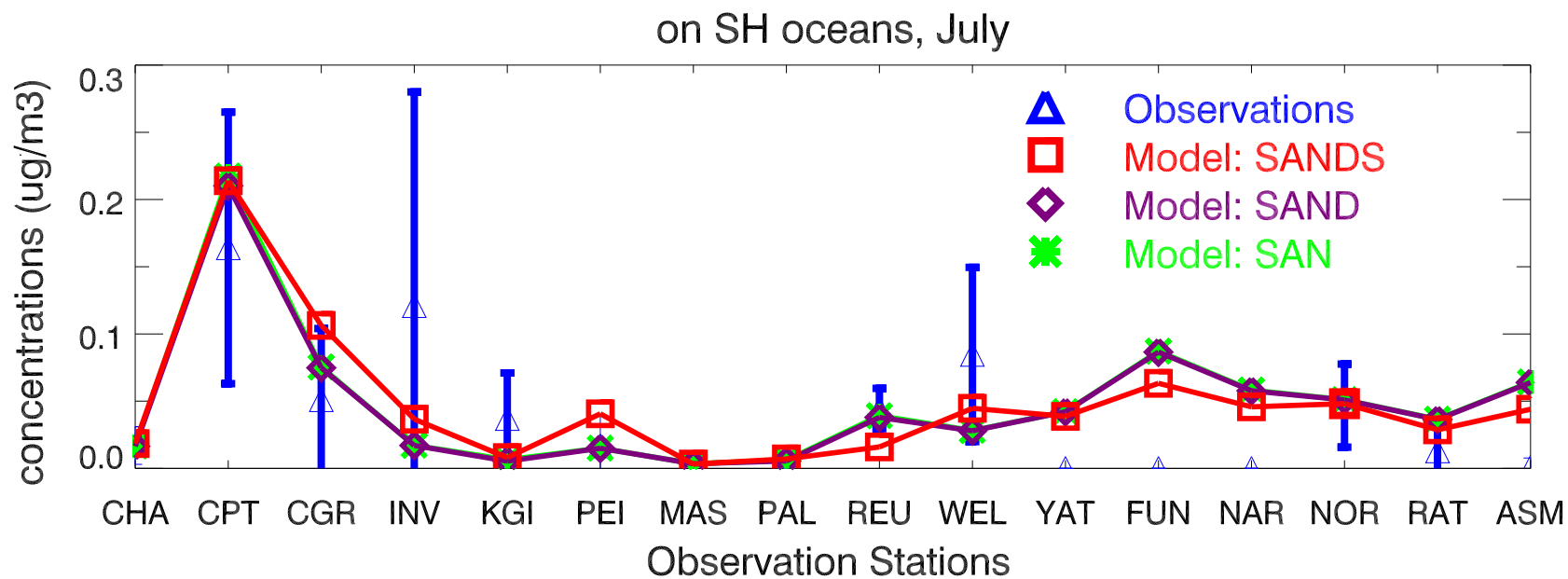
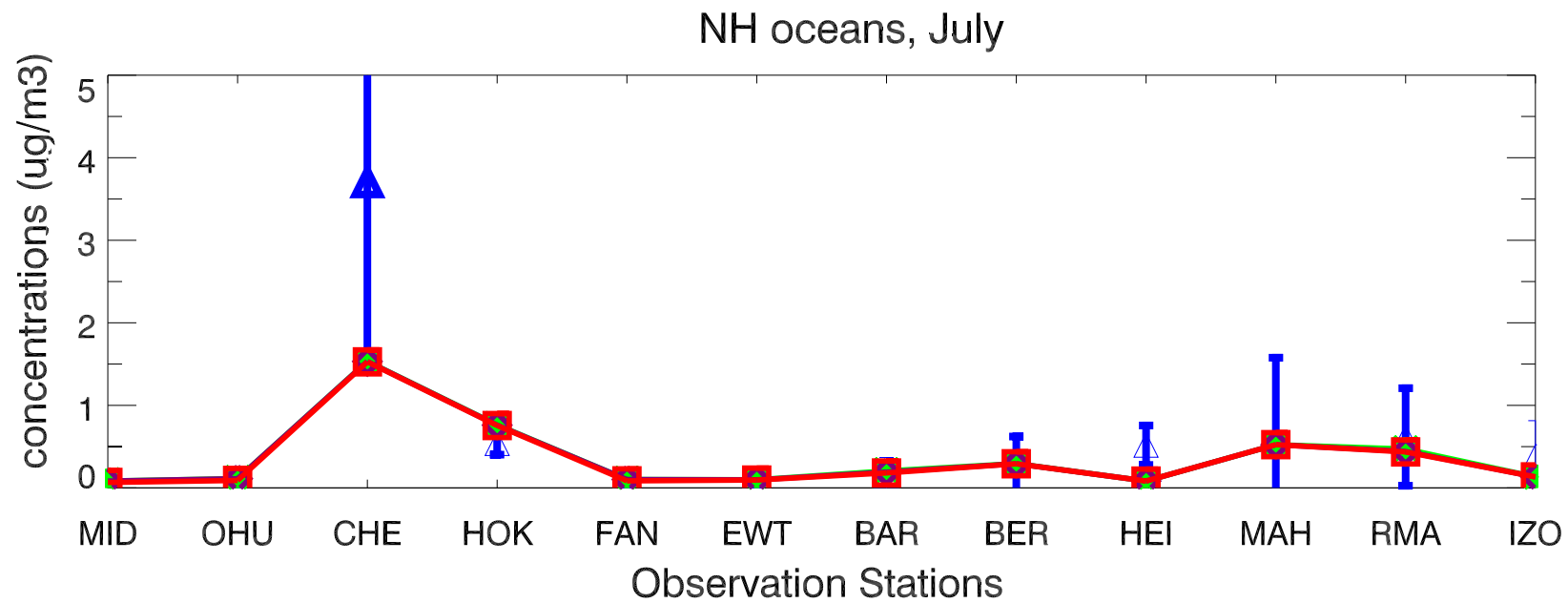
NH oceans, January



on SH oceans, January

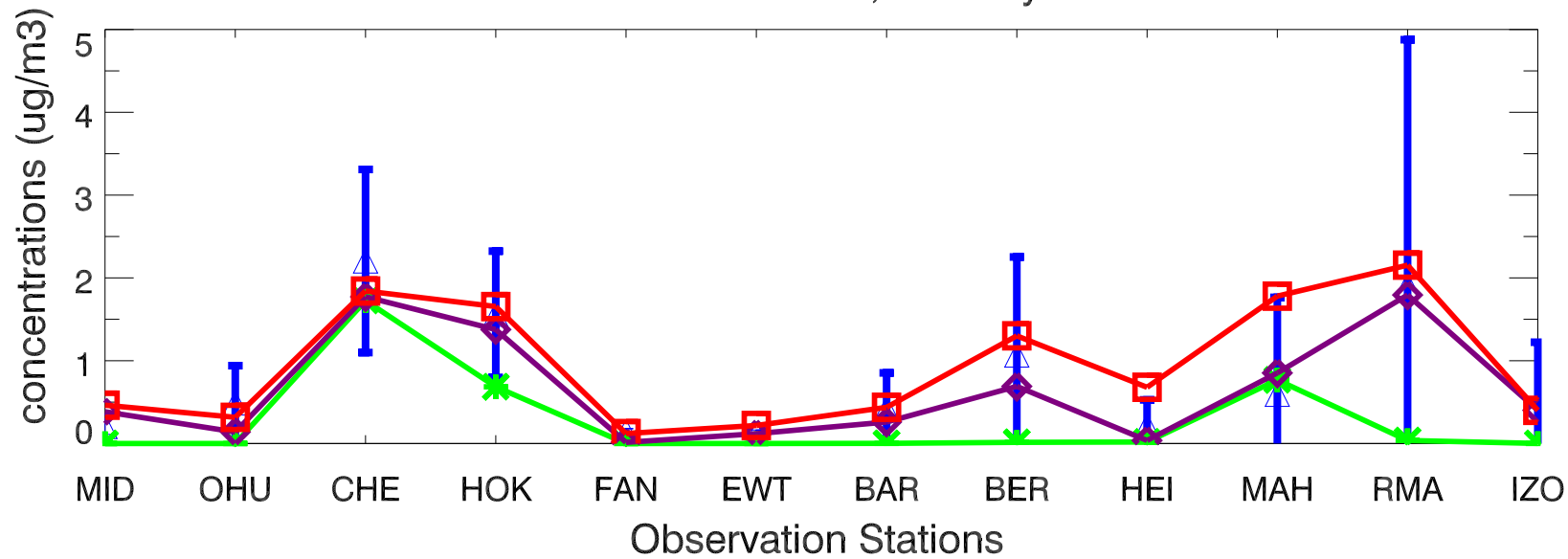


Comparison of NH₄- surface concentrations to observations

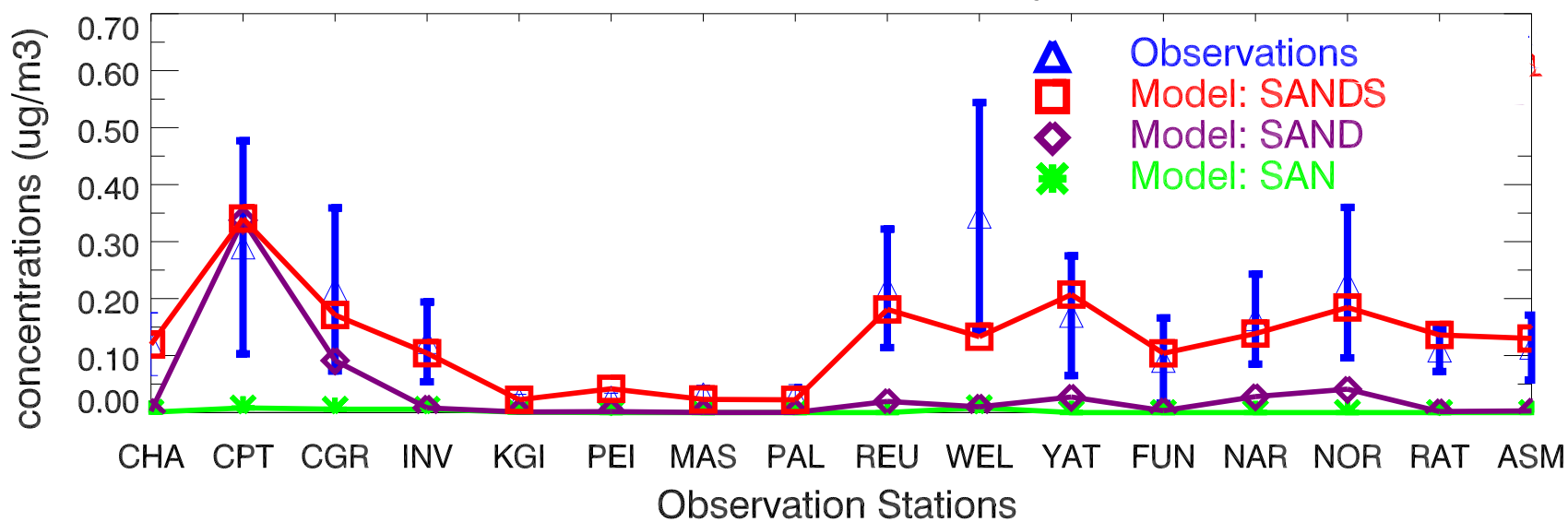


Comparison of NO₃⁻ surface concentrations to observations

NH oceans, January

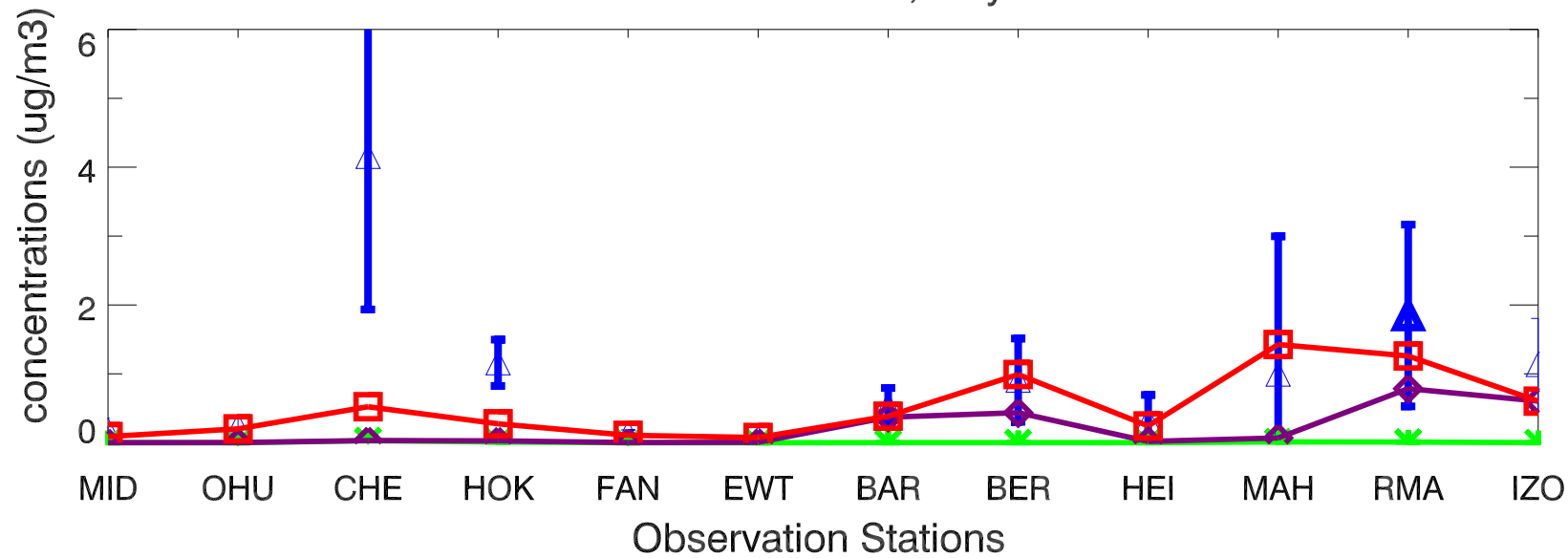


on SH oceans, January

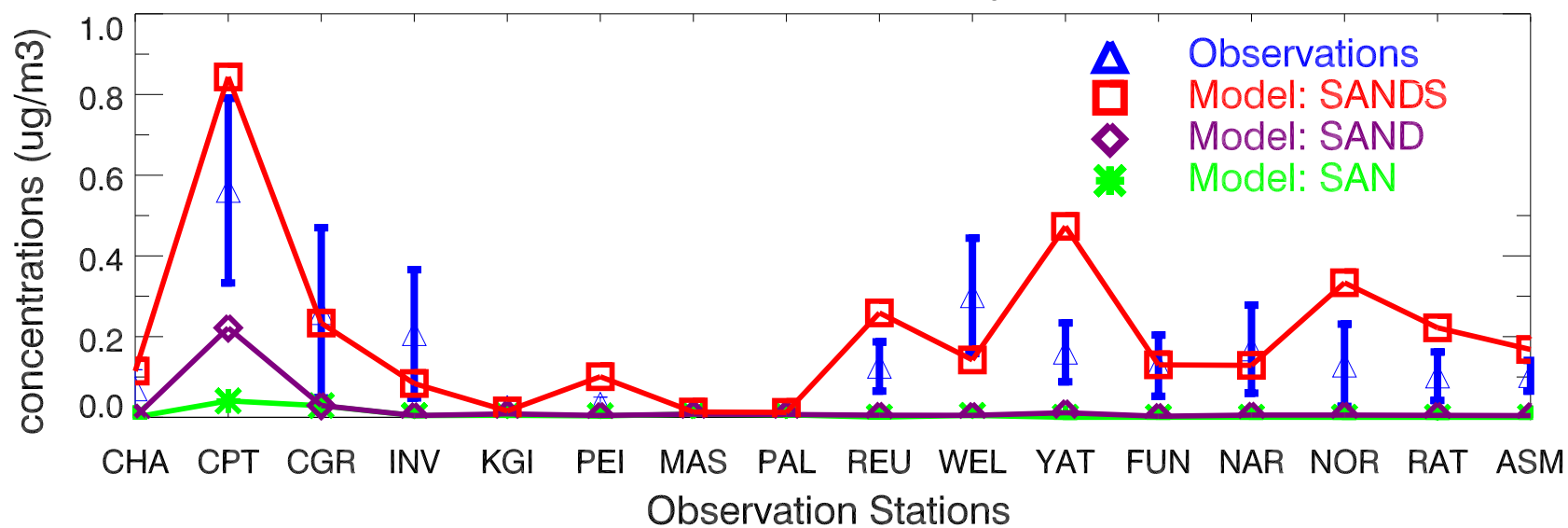


Comparison of NO₃⁻ surface concentrations to observations

NH oceans, July

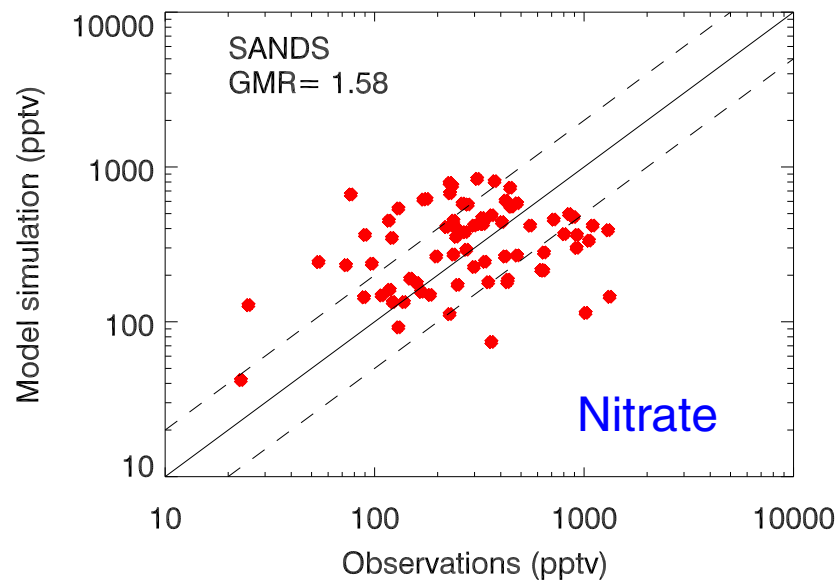
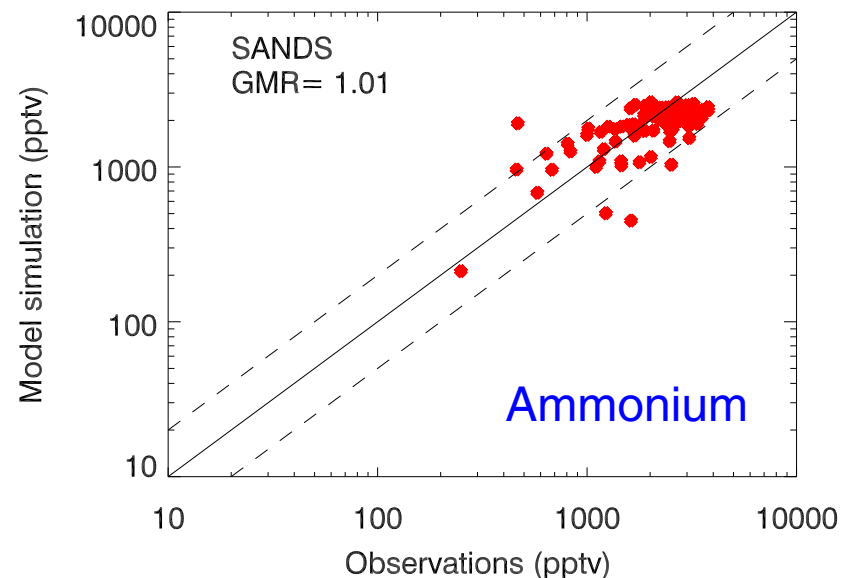
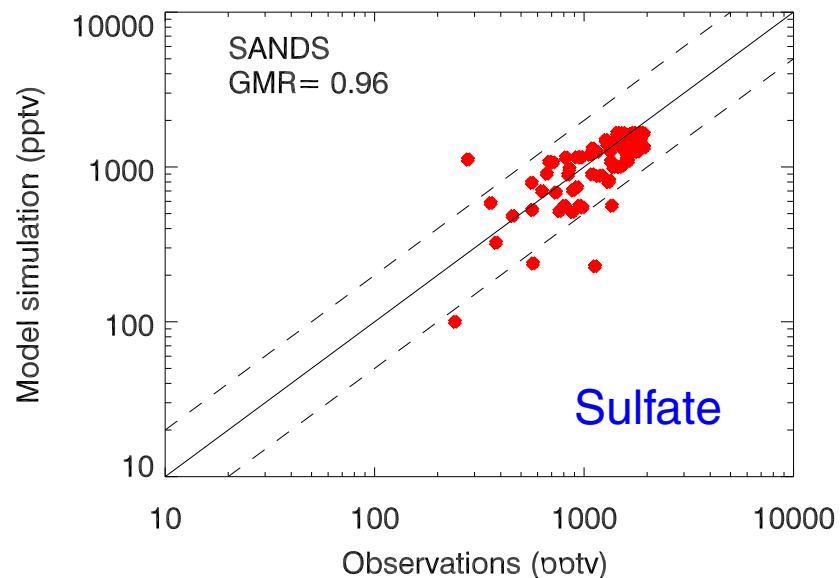


SH oceans, July



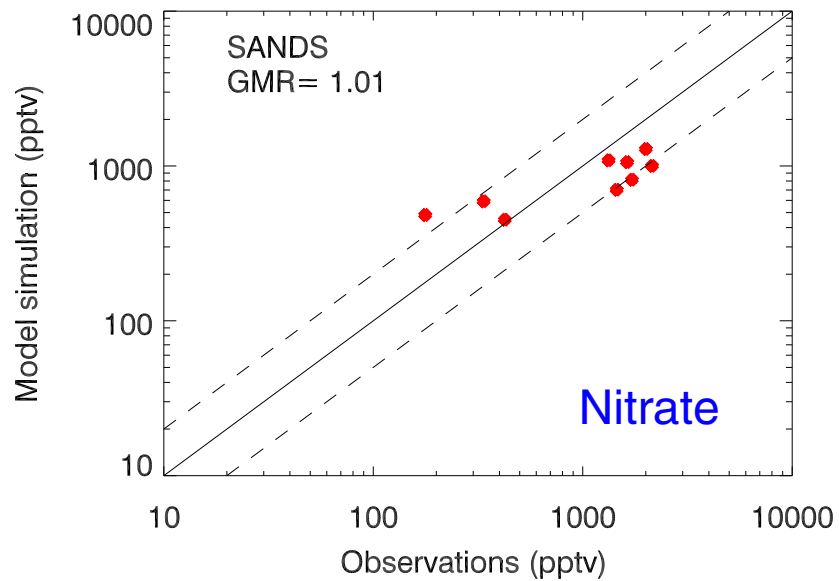
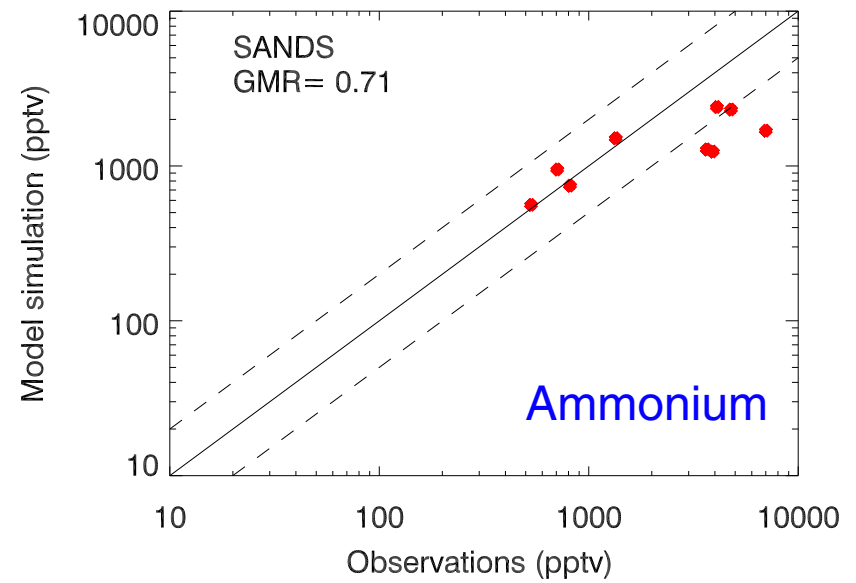
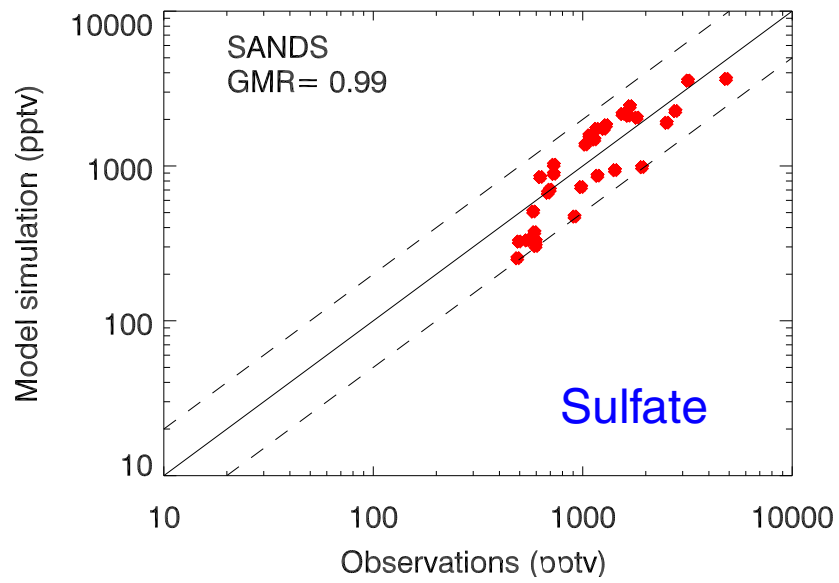
Comparison of modeled and observed surface concentrations in North America

EMEFS data from 1988-1990



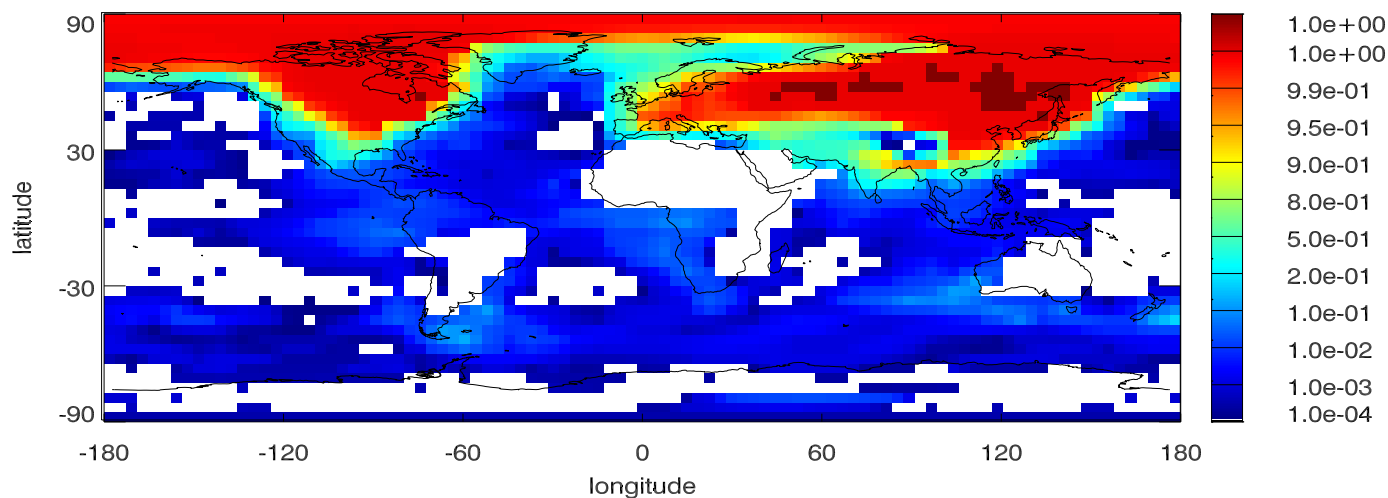
Comparison of modeled and observed surface concentrations in Europe

EMEP annual data from 1990

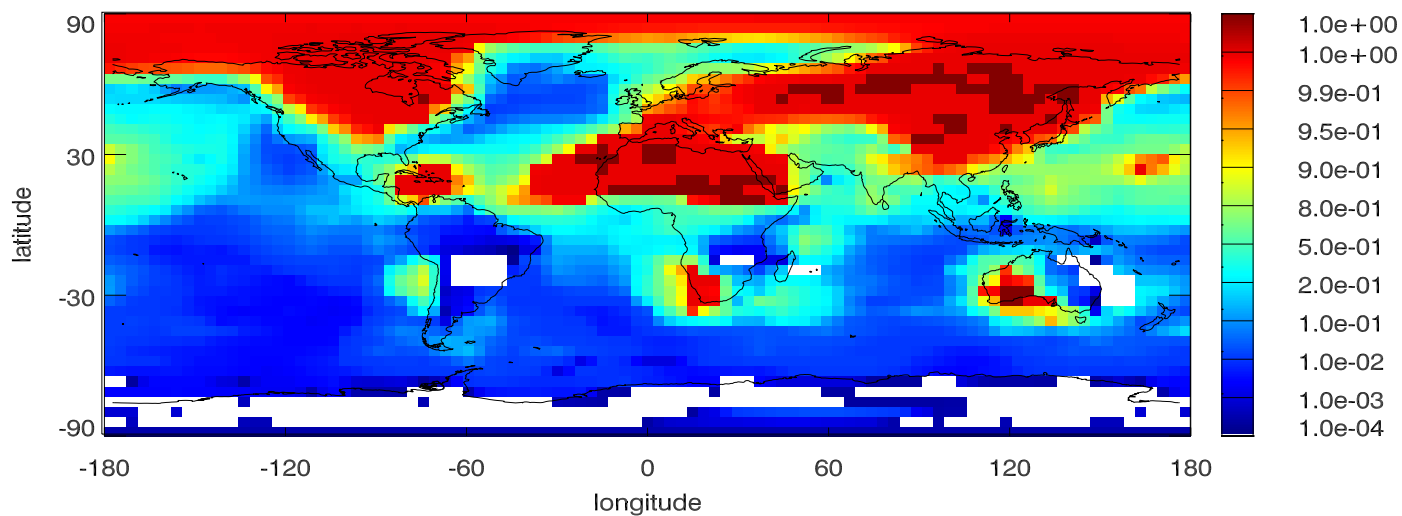


Fraction of nitrate in aerosol at the surface in January

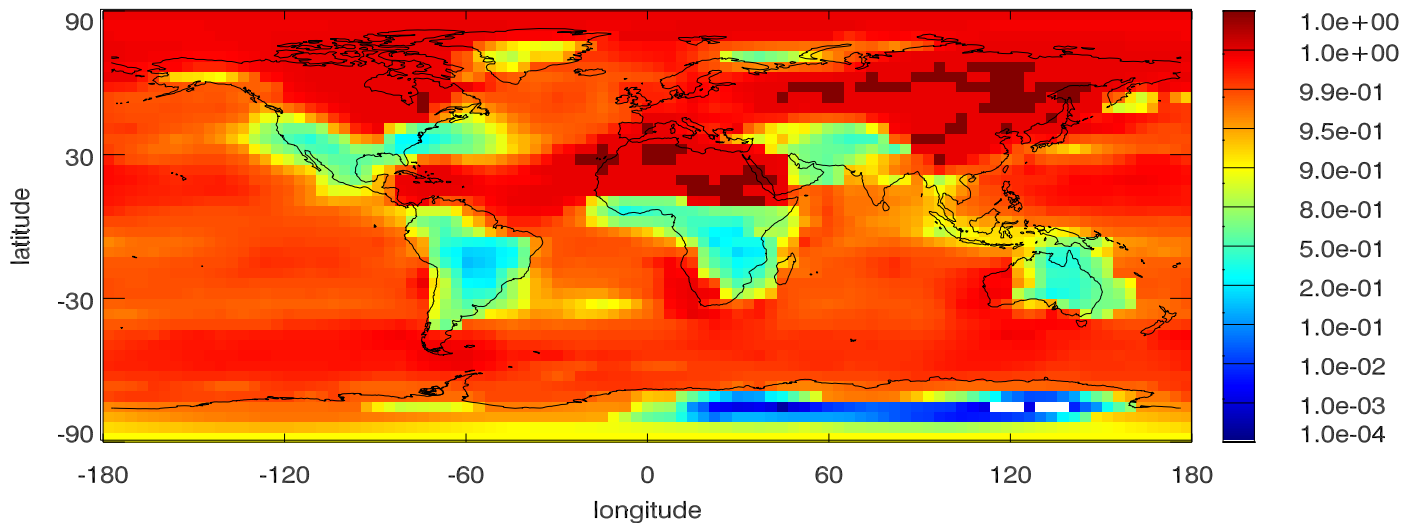
Sulfate, nitrate, ammonia



with dust

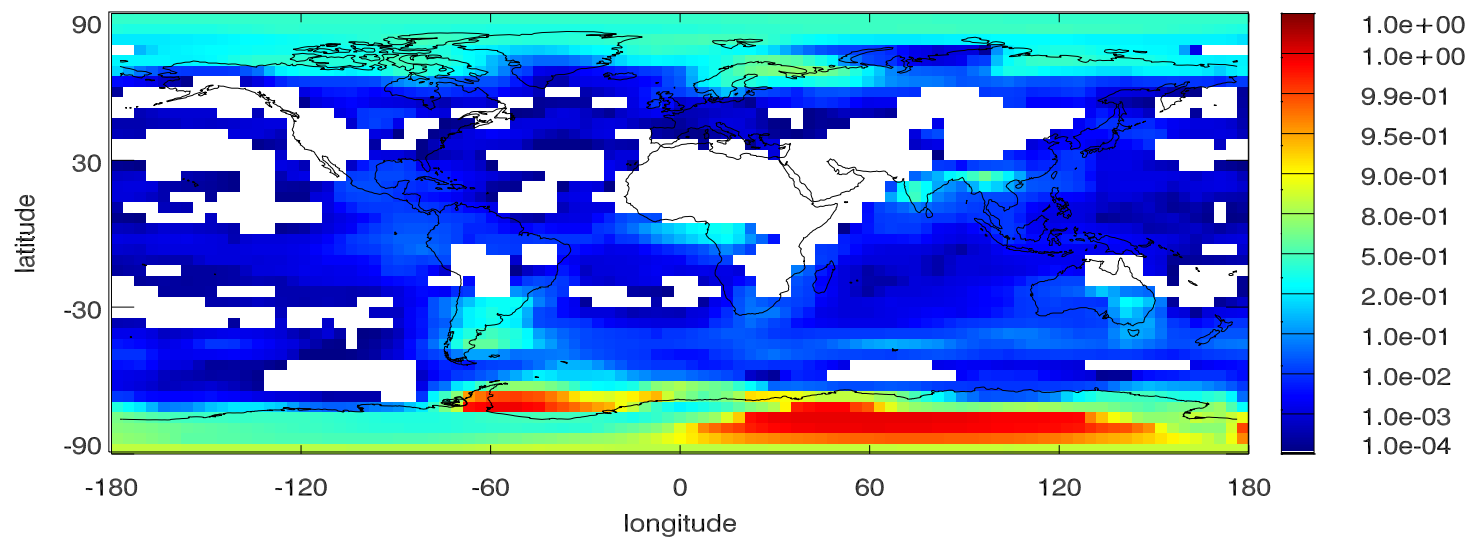


with dust, seasalt

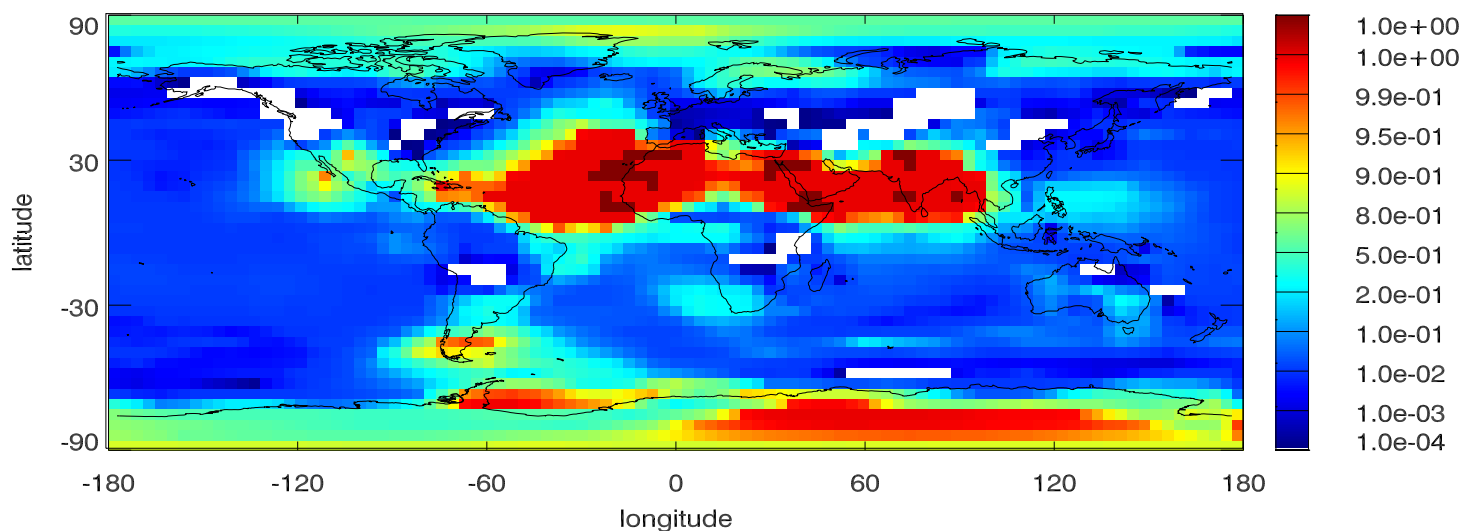


Fraction of nitrate in aerosol at the surface in July

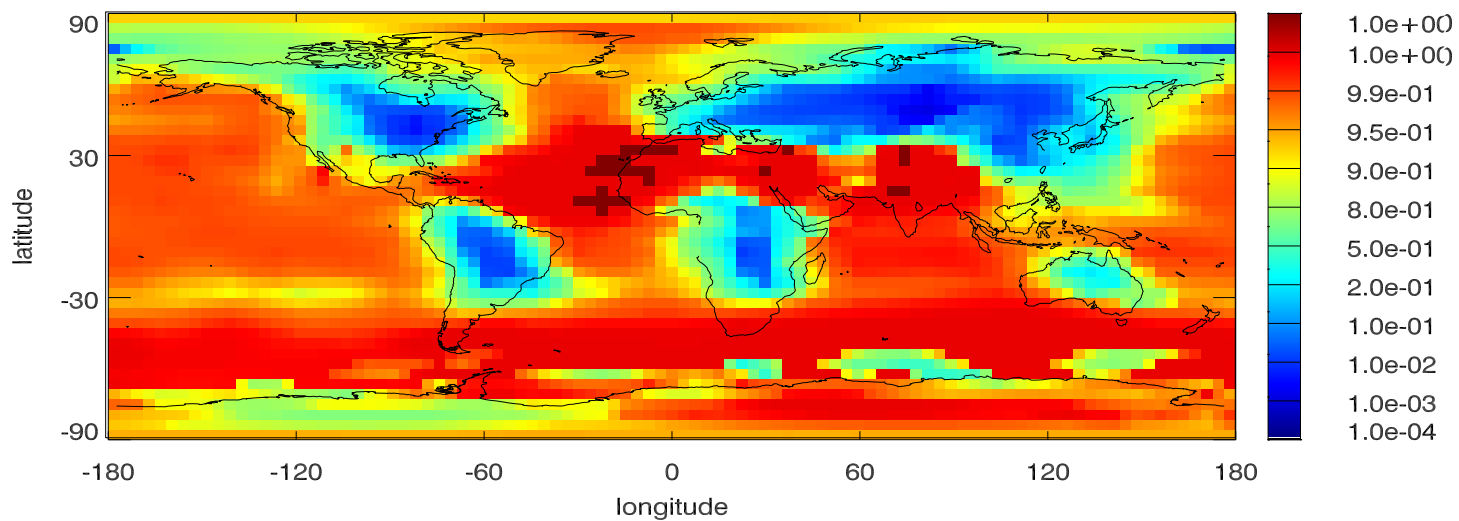
Sulfate, nitrate, ammonia



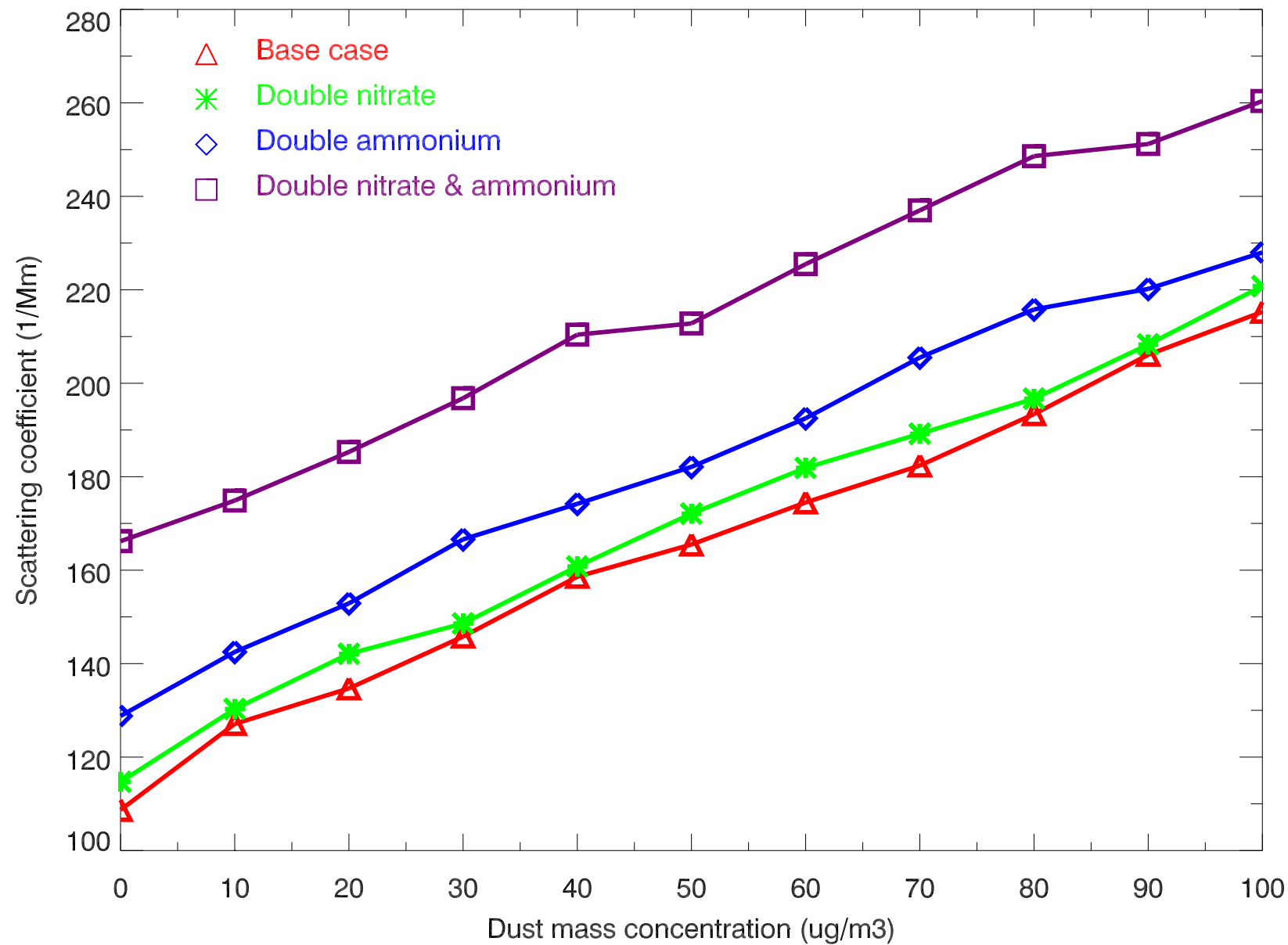
with dust



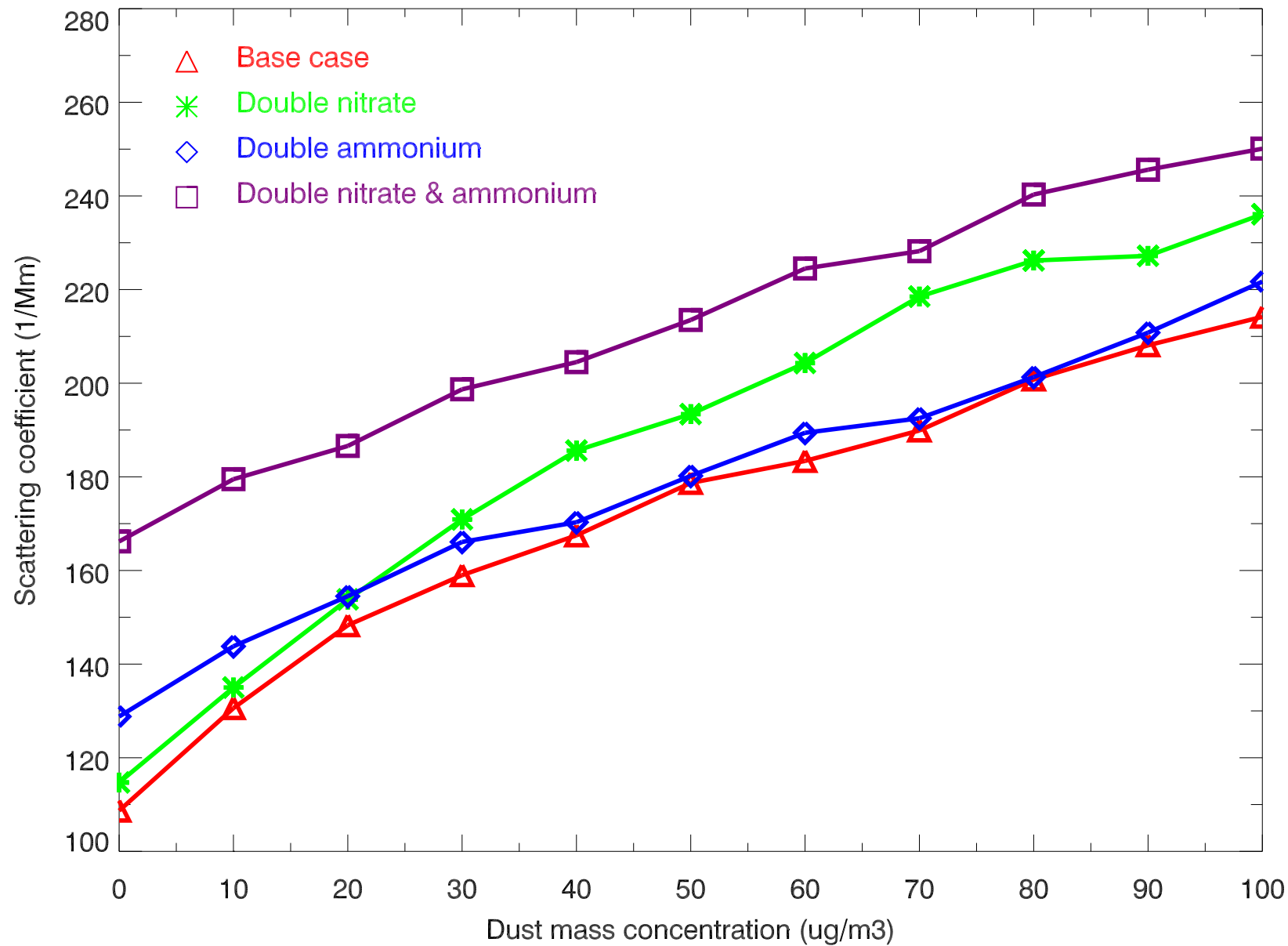
with dust, seasalt



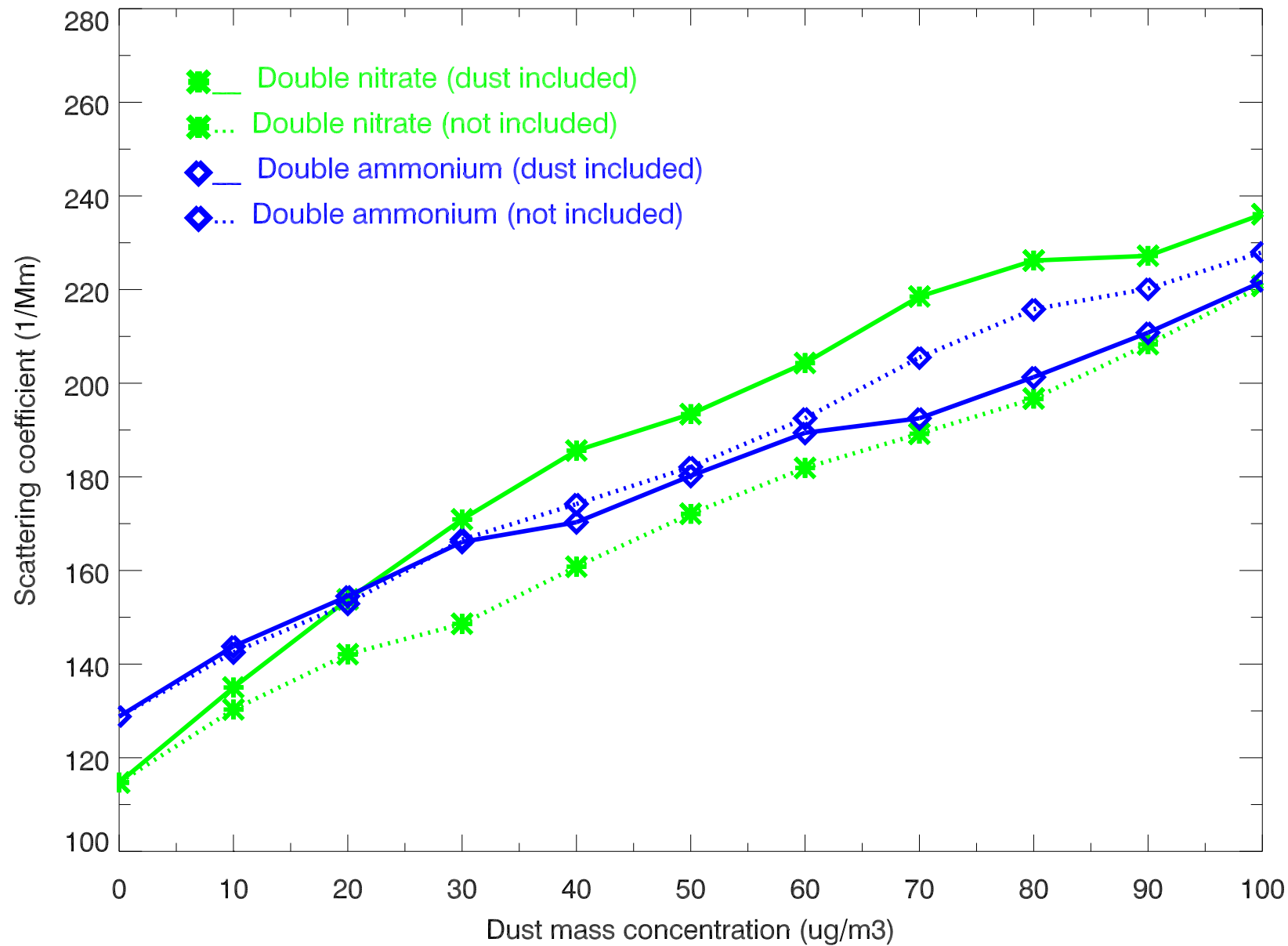
Dust is not included in equilibrium



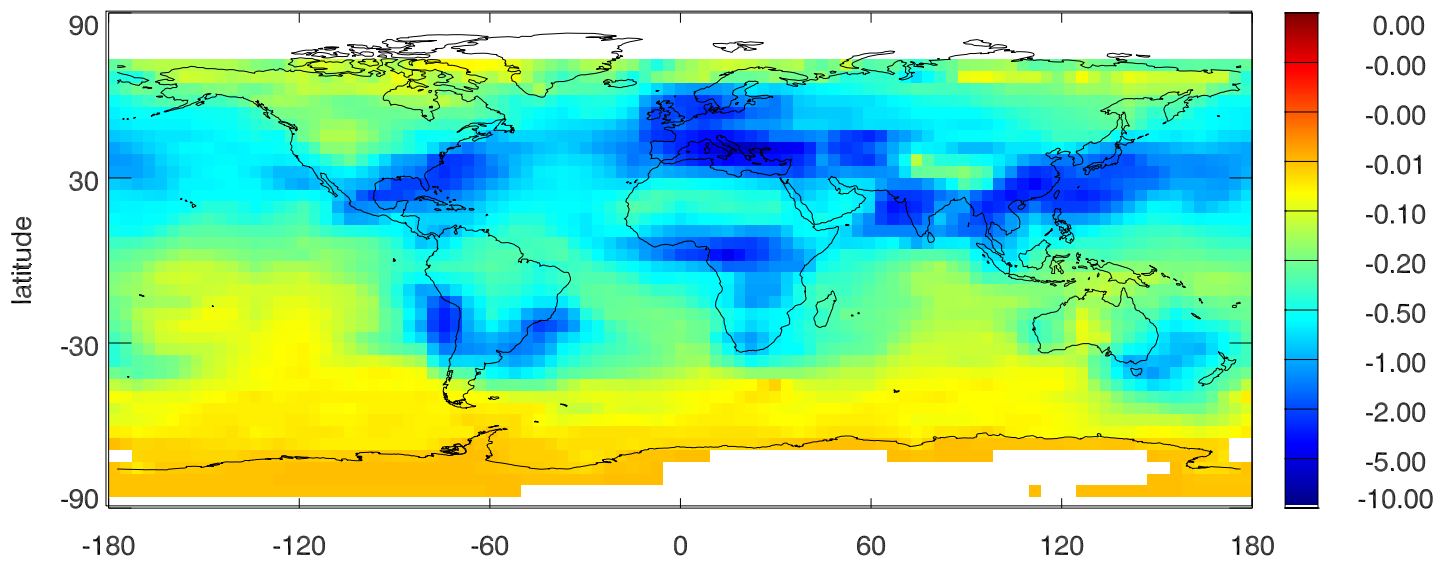
Dust is included in equilibrium



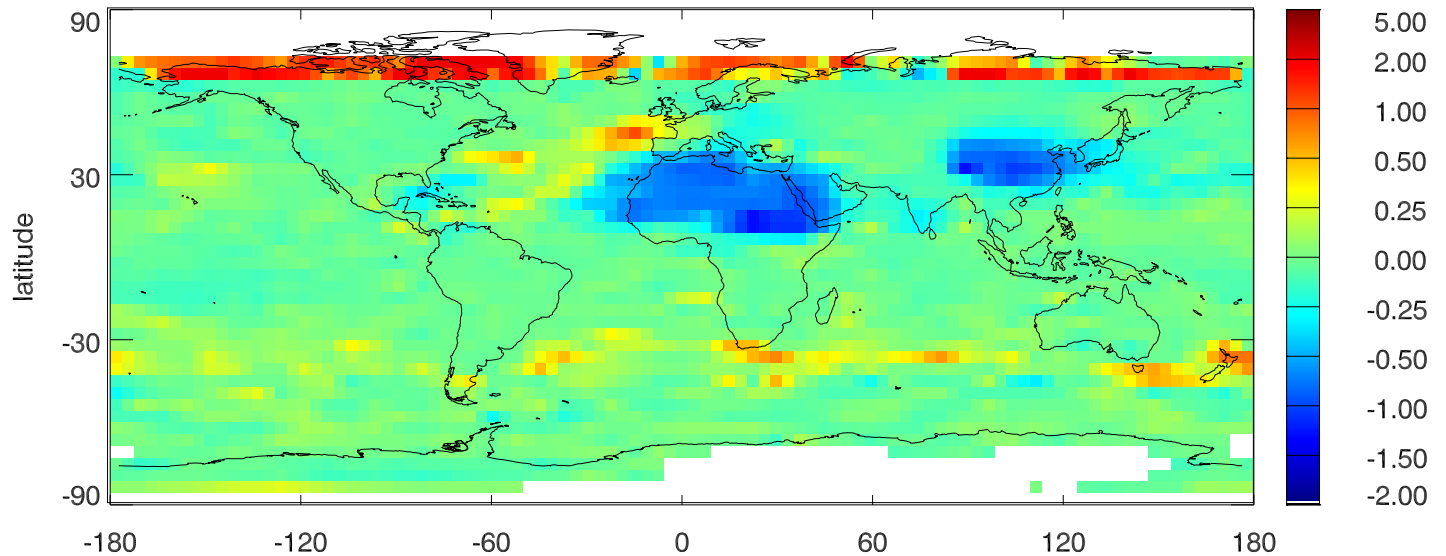
Dust included/not included in equilibrium



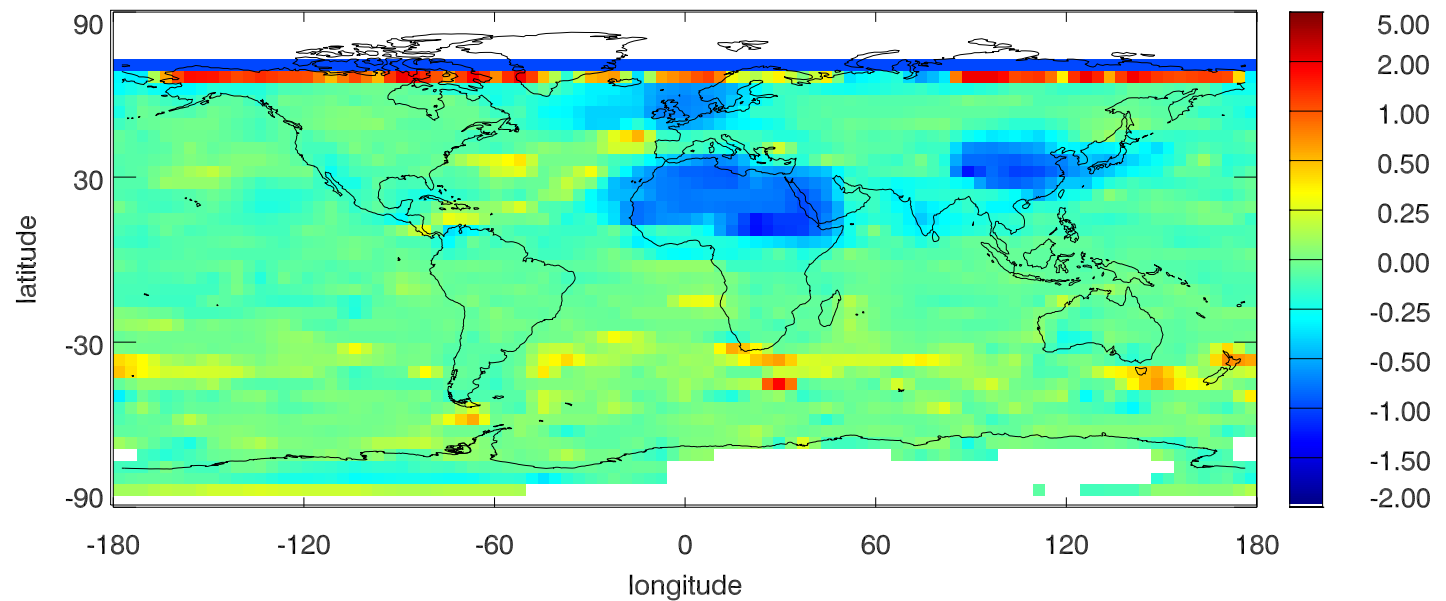
Clear-sky Forcing(SAN) on TOA, JAN,



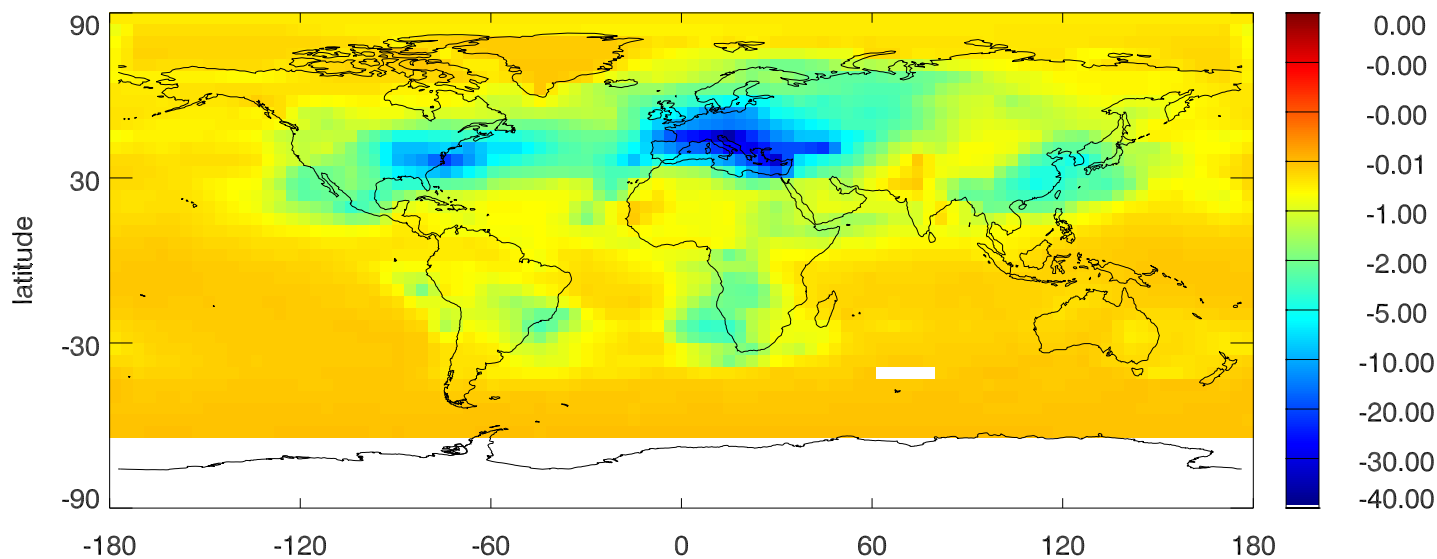
$(\text{Forc}(\text{SAND}) - \text{Forc}(\text{SAN})) / \text{Forc}(\text{SAN})$ on TOA, JAN,



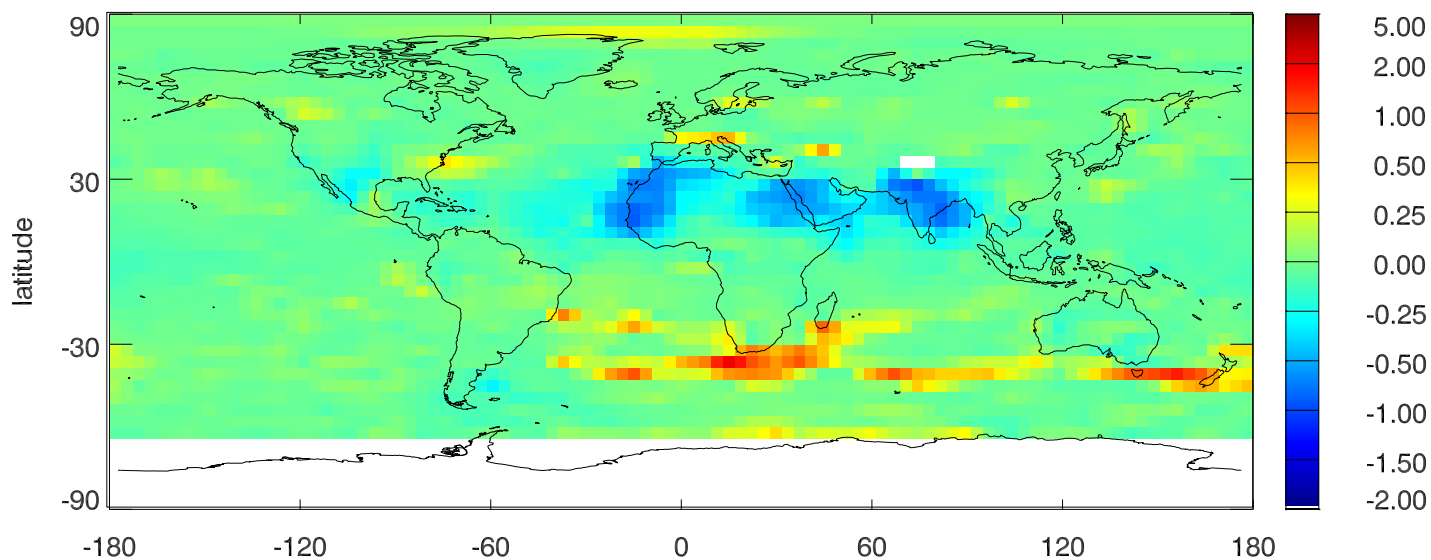
$(\text{Forc}(\text{SANDS}) - \text{Forc}(\text{SAN})) / \text{Forc}(\text{SAN})$ on TOA, JAN,



Clear-sky Forcing(SANDS) on TOA, JULY,



$(\text{Forc}(\text{SAND}) - \text{Forc}(\text{SAN})) / \text{Forc}(\text{SAN})$ on TOA, JULY,



$(\text{Forc}(\text{SANDS}) - \text{Forc}(\text{SAN})) / \text{Forc}(\text{SAN})$ on TOA, JULY

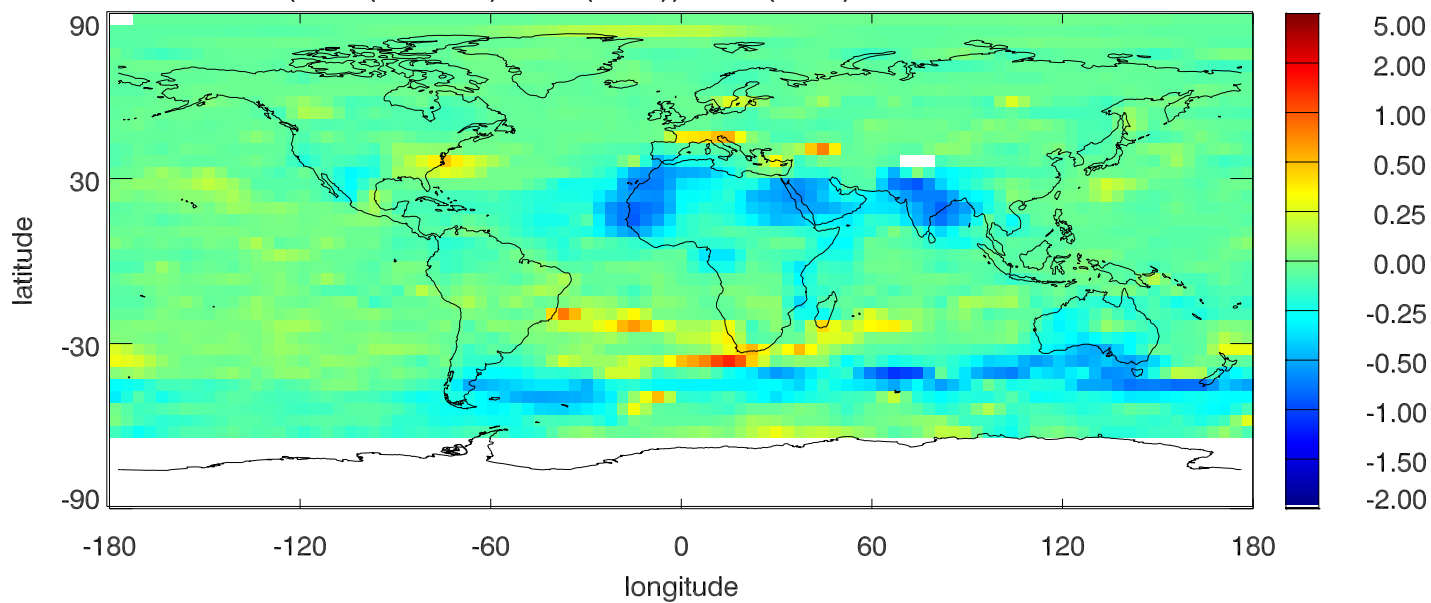


Table: Total aerosol and gas phase burdens in the atmosphere

	H2SO4	NO3-	HNO3	NH4+	NH3	Dust	SeaSalt
	(Tg S)	(Tg N)	(Tg N)	(Tg N)	(Tg N)	(Tg)	(Tg)
H2SO4+HNO3+NH3	0.62	0.12	1.34	0.28	0.38	-	-
H2SO4+HNO3+NH3 +DUST	0.62	0.16	1.34	0.26	0.38	28.83	-
H2SO4+HNO3+NH3 +DUST+SEASALT	0.62	0.25	1.34	0.26	0.38	28.83	5.15

Estimated forcing associated with different chemical representation of the aerosol (Wm^{-2})

	Forcing based on monthly- averaged-RH	Forcing based on constructed max-RH	Forcing based on daily varying RH
H ₂ SO ₄	-0.45	-0.56	-0.47
H ₂ SO ₄ +NH ₃	-0.39	-0.51	-0.47
H ₂ SO ₄ +NH ₃ +HNO ₃	-0.42	-0.58	-0.47
H ₂ SO ₄ +NH ₃ +HNO ₃ +DUST	-0.40	-0.52	-0.43
H ₂ SO ₄ +NH ₃ +HNO ₃ +DUST+SEA SALT	-0.38	-0.50	-0.42
H ₂ SO ₄ +NH ₃ +HNO ₃ (Year: 2100)	-0.57	0.83	-0.62

Conclusion.

- **A significant fraction of the total nitrate and ammonia are incorporated within the aerosol, especially in areas with high dust and sea salt concentrations**
- **This leads to an overall decrease in climate forcing compared to that calculated for sulfate aerosols alone (-0.42 Wm^{-2} compared to -0.47 Wm^{-2})**
- **If future concentrations of NO_x emissions continue to increase, the forcing by the combined sulfate, ammonium, and nitrate aerosol may increase to -0.62 Wm^{-2}**